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THE JOURNAL OF ENGINEERING EDUCATION

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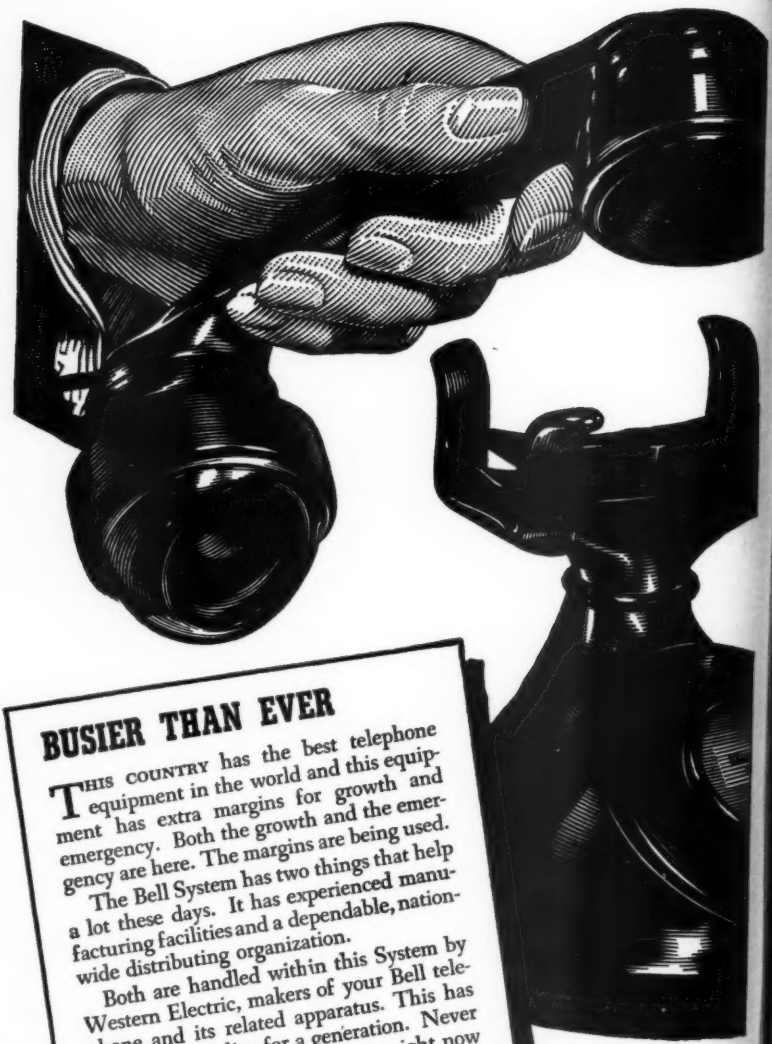

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Published monthly (except during July and August) by the Society for the Promotion of Engineering Education

Published under the Supervision of the Publication Committee.
D. B. Prentice, O. J. Ferguson, F. L. Bishop, Editor, University of Pittsburgh.
Published at Prince and Lemon Sts., Lancaster, Pa.

Entered as second-class matter at the Post Office at Lancaster, Pa., under the Act of August 12, 1912.

New Series
Vol. XXXI, No. 8 APRIL, 1941 Subscription Price, $3.00 per year. Single Copies, 50 cents

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ENGINEERING DEFENSE TRAINING LOOKS AHEAD

By ROY A. SEATON *

With many of the earlier and shorter Engineering Defense Training courses now approaching completion and with 135 engineering colleges now authorized to give instruction to more than 77,000 EDT students, it is opportune to take stock of the present situation and to look forward into the immediate future.

The need of defense industries and government agencies for additional engineering personnel continues to grow. William S. Knudsen, Director General of the Office of Production Management, recently stated: "Nothing short of the practical limit of our available productive capacity is sufficient for the defense job we have now undertaken." He estimated that the present labor level in defense production will soon be increased 60 per cent. Figures compiled recently by the Office of Production Management show that "direct defense expenditures (in this country) for United States and British account, authorized and proposed, amount to $42,688,800,000" while "expenditures against these sums made by the United States Treasury from June 1, 1940 through March 17, 1941, totaled $3,456,000,000." An immense volume of work remains to be done.

In our all-out defense effort the maximum volume and speed of production will depend upon some physical factor such as the amount of materials available or the capacity of the plants or the number of qualified men available to operate the machines, supervise production, or manage the plants. It is the obligation of the U. S. Office of Education and the engineering schools to see that adequate training is provided so that a shortage of competent engineers shall not become the controlling factor in our defense production. They must make sure that defense industries and defense government agencies can obtain the necessary engineering personnel as it is needed.

Our job is not an easy one. While it is clear that the overall requirements of the defense program for additional engineering personnel will be large, to provide the specific kind of training required at the rate that the trainees can be absorbed calls for constant alertness, frequent revisions of plans, and the closest possible rela-

* Dean of the Division of Engineering and Architecture, Kansas State College, absent on leave to serve as Director of Engineering Defense Training in the U. S. Office of Education.

tions with the defense industries. While we have now made a good start, we cannot afford to relax our efforts and our vigilance until our work is fully accomplished.

Because of the rapidity with which the Engineering Defense Training program has developed, statistical data on the results lag far behind actual accomplishments. Enough data have been received, however, to indicate a definite need for more pre-employment training, as contrasted with in-service training. This does not mean that the latter type of training is not valuable or even indispensable. Up-grading of present employees in defense plants through intensive training courses is the obvious method of filling vacancies in the upper levels of responsibility. But who is going to replace the men thus moved up the ladder? Who is going to staff the hundreds of new plants and plant additions that are now under construction? But, important as in-service training undoubtedly is, it can meet only part of the need that must be met if we are fully to discharge our obligations.

Many institutions, through effective publicity, have had marked success in attracting qualified students for full-time courses. Many other institutions can contribute materially to the success of our defense program by increasing their efforts to organize such courses, or by organizing additional full-time courses.

The coming summer offers a special opportunity to stress this type of training. Faculty members and facilities of engineering schools will be relieved of their regular academic loads. Industrial needs will have become more definite. Prospective students will, in many cases, find it more feasible to devote their full time to defense training, particularly as the probability of subsequent employment can be clearly demonstrated. Large numbers of recent high-school graduates who cannot go on to college, and college students, both in liberal arts and engineering, who cannot continue their college work will become available.

This chance must not be missed. I hope that every eligible engineering school, regardless of the extent of its present participation in the EDT program, will plan next summer to go "all out" in utilizing its facilities and its staff in discharging the most important obligation that has ever been laid upon American engineering colleges, the obligation "to meet the shortage of engineers with specialized training in fields essential to the national defense."

MICHIGAN AS HOST FOR THE JUNE MEETING

By IVAN H. WALTON

The University of Michigan is preparing a warm welcome and an interesting, diversified, and instructive session for those members of the Society for the Promotion of Engineering Education and their families who are able to come to Ann Arbor next June for the 49th annual national meeting of the Society.

Michigan, the center of the storied Great Lakes country with her 4,000-mile coast line and her diversified landscape and climate, invites you to enjoy her unique and ample summer vacation advantages, and the University cordially invites you to her campus to meet with the 2,500 other expected guests in a democratic exchange of ideas that bodes well for engineering education.

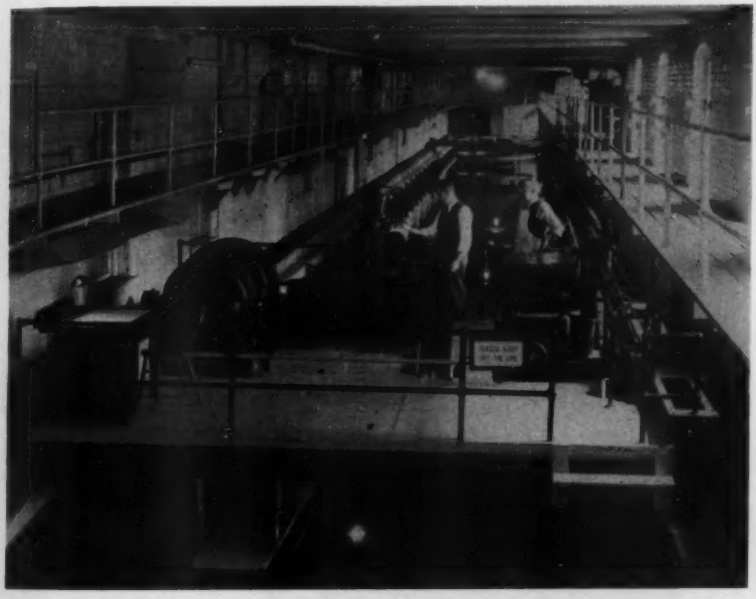
In the December issue of the JOURNAL, Professor J. R. Nelson informed you of some of the highlights in the University's history and outlined briefly the development of the College of Engineering. A later article will mention some of the available side tours to points of natural and industrial interest. The following paragraphs will describe briefly some of the special features of the College of Engineering which, because of their degree of uniqueness and instruction and research value, should be of interest to visiting members of the Society.

At the present time the College of Engineering occupies completely four buildings in the southwest section of the main campus and utilizes the facilities of several others. It has a teaching staff of 120 members exclusive of the men teaching allied sciences, and it offers instruction on both the undergraduate and graduate level in Aeronautical, Electrical, Marine, Mechanical, Metallurgical, and Transportation Engineering, and in Engineering Drawing, Mechanics, and Physics, and also in Metal Processing, in Geodesy and Survey, and in English. This diversity of instruction has necessitated a wide variety of equipment, and some of it is not duplicated in many other places.

The University's experimental naval tank has long enjoyed a considerable uniqueness. The special interest of Dean Emeritus M. E. Cooley, who came to the University direct from the United States Naval Academy, and the proximity of the enormous shipping activity on the Great Lakes made it inevitable that when the spacious West Engineering Building was constructed in 1906 it

LAW QUADRANGLE

should contain a large, well-equipped, naval towing basin. At the time of its construction, it was preceded on this side of the Atlantic only by the tank at the Government Navy Yard at Washington, D. C., and it is still the only one of its kind in an American university. In it was done the experimental work that made possible the development of the 15,000-ton, bulk-carrying, steel freighters that dominate traffic on the Great Lakes today, and here also were developed the designs of the fast side-wheel passenger liners that during the summer months carry thousands of passengers the length



NAVAL TANK IN THE WEST ENGINEERING BUILDING

of the lakes and especially between Detroit, Cleveland, and Buffalo. The tank is equipped with an adjustable bottom so that conditions on shoal rivers can be simulated and experimental work done on flotilla and individual barge forms.

The College is also proud of its Highway Testing Laboratory, which is maintained jointly by the Michigan State Highway Department and the University both for instruction and for research purposes. It contains a special soil mechanics laboratory and is completely equipped to make all soil and materials tests necessary

to modern highway construction. Information, procedures, and research tools obtained from this laboratory have enabled the University of Michigan to do much pioneering highway work and to be one of the first to offer a varied curriculum in this increasingly important branch of engineering.

DIAGONAL WALK ON THE MAIN CAMPUS

Closely associated with the practical work of the laboratory is the historical research made possible by the University's entirely unique Transportation Library of over 100,000 items. Housed in the East Engineering Building, this collection of pictorial material, rare manuscripts, biographical, historical, and more modern writ-

ings relating to all phases of transportation is easily available to students and others interested in it. In this connection, attention should also be called to the Clements Library of American History, an extensive and invaluable collection of early Americana. The materials and the building which houses them were gifts of the late William L. Clements, a prominent engineer of Bay City, Michigan, who was also an alumnus and for many years a regent of the University.

GENERAL UNIVERSITY LIBRARY

The recent development of aeronautical testing laboratories and wind tunnels, particularly those at government testing stations, has detracted somewhat from the early interest in Michigan's pioneer eight-foot, and the smaller two-by-three-foot 100 m.p.h. tunnels in which were developed the famous "Airocobra" and "Airacuda" planes and the earlier Lockheed models. The dynamometer installed in the laboratory for the study of wheel and shock-absorber action will, however, be of interest to visiting engineers.

The University's relatively new Machinability Laboratory is unique in its up-to-dateness and completeness. It is fully equipped for instruction and for fundamental research in the machinability

of metals and in the use of cutting tools and fluids. It includes a machine-tool laboratory on the first floor of the East Engineering Building; a heat-treating, molding, and metal-working laboratory on the third; and on the fourth a foundry for studying problems associated with cast metals. The University is also custodian of the Gaging and Measuring Laboratory, belonging to the Detroit Ordnance district of the U. S. Army. It contains all types of precision measuring equipment, accurate to a millionth of an inch, for checking linear and angular dimensions.

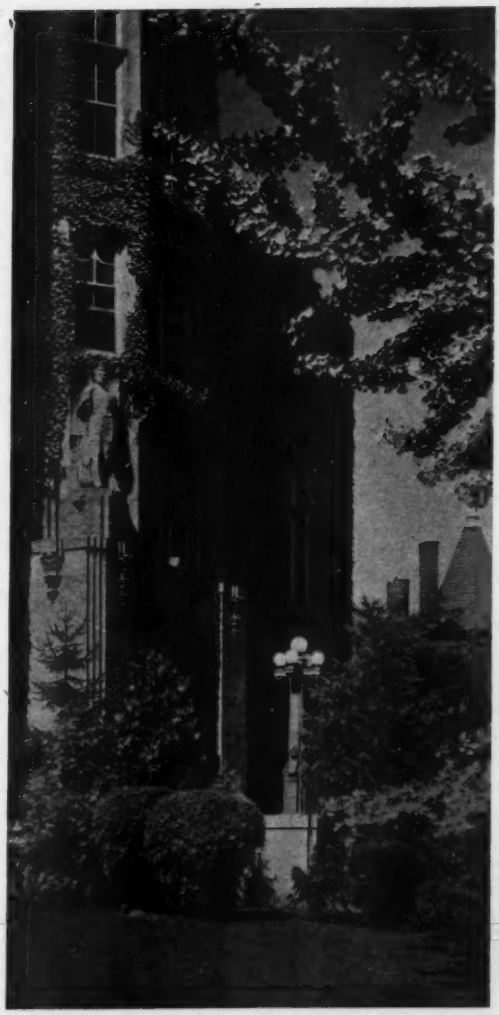
Other engineering laboratories contain recently developed apparatus for demonstrating the laws of fluid mechanics by projecting flow patterns on a screen; for making motion-time studies in industrial engineering; for making photoelectric investigations; for petroleum research; for studyng various qualities of paper; and for determining creep characteristics of metals at elevated temperatures. The college also has equipment for investigating methods of air purification in industrial plants; for determining the characteristics of domestic stokers and stoker coals; for demonstrating critical speeds of rotating shafts and for studying different forms of unbalance in rotating parts; for illustrating different forms of vibration damping; and for studying combustion in Diesel engines at speeds up to 2,000 r.p.m. Some special electrical apparatus has been developed for calibrating and standardizing a wide variety of electric metering equipment; for demonstrating frequency modulations; for the study of fractional horse power motors; and for investigating the nature of fast transients in industrial electronic equipment.

Other University apparatus includes a hydrocal, a device for automatically solving complicated problems that arise in the study of heat-flow transients; an acoustical capacimeter for automatically determining the volume of small containers; and a completely isolated reverberation chamber and equipment for studying noise.

For promoting basic physical research, the University has a million-volt transformer for nuclear investigations and a completely self-contained electron microscope that operates on a current up to 60,000 volts and has a resolving power of fifty millionths of a centimeter.

The apparatus for spectrochemical research is equipped with a 40,000-volt controlled spark source, various alternating and direct current arcs, a high precision microphotometer, a spectrograph and other instruments. The apparatus has made possible the development of a six-minute control analysis of iron and steel for industrial application.

The University's infrared spectroscopy laboratory, one of the foremost in the world, is fully equipped for the study of molecular



MAIN ENTRANCE TO MICHIGAN UNION

structures, especially those of organic substances. The equipment is now being applied by manufacturers of organic chemicals.

Another piece of equipment, the University's ten and one half million-volt cyclotron, well deserves mention. It is the second largest and most powerful in America and contains over 90 tons of copper and steel. Physical research made possible by its use has already yielded over one hundred radioactive isotopes.

Your prospective hosts will gladly demonstrate to you any of their standard or special equipment during the Society's meeting in Ann Arbor next June. The State of Michigan and the University most cordially invite you to be present.

REPORT ON S. P. E. E. CONFERENCE ON SOIL MECHANICS AND ITS APPLICATIONS

Introduction

During the week of September 2 to 6 inclusive, 1940, a conference on soil mechanics and its applications was held at Purdue University. The conference was sponsored by the Committee on Soil Mechanics and Foundations, Civil Engineering Division of the Society for the Promotion of Engineering Education, and by the School of Civil Engineering and the Engineering Extension Department of Purdue University.

Proceedings

Prior to the meetings of the conference, Proceedings, consisting of four symposiums on soil mechanics instruction and fifty papers on various aspects of soil mechanics and its applications, were distributed to members. Papers for the Proceedings were submitted during June, and the Proceedings were prepared and printed during July and August, 1940. The purpose of advance distribution of the Proceedings was to enable the members of the conference to discuss the several papers during the meetings. Fifty-five authors contributed to the papers and symposiums in the Proceedings, several of whom contributed two or more papers. Six hundred copies of the Proceedings, printed by the photo-offset process, consist of four hundred and ninety-two liberally illustrated pages and are bound in a stiff brown paper board cover. By special permission of Joel D. Justin, Chairman of the American Society of Civil Engineers' Committee on Sampling and Testing of Soils, an eighty-eight page report on the committee's work on sampling of undisturbed soils by M. J. Hvorslev was reprinted and distributed with the Proceedings. All miscellaneous expenses of the conference and all costs in connection with the preparation and printing of the Proceedings were paid by Purdue University. The Proceedings have been sold to members of the conference and other interested persons at four dollars per copy, the proceeds being paid to the University to offset the expenses of the Conference.

Financial Report

Expenses paid by funds from the Purdue Engineering Extension Department:	
Stenographic labor	$ 459.55
Drafting labor	53.70
Supplies and incidentals	45.24
Printing programs	28.50
Printing Proceedings	*1,290.75
Mimeographing announcements	25.75
Postage for announcements and Proceedings	165.28
Total expenses	$2,068.77
Receipts from Sale of Proceedings:	
373 Paid by check, money order, or cash	$1,492.00
17 Paid $2.00 by Purdue students	34.00
136 Library and government orders	544.00
2 Payment not yet received (foreign)	8.00
Total receipts	$2,078.00

66 Complimentary copies to authors, S. P. E. E. officials, Purdue University officials, Purdue Library, Library of Congress, etc.
2 Copies to replace lost or defective copies.
2 Copies paid in stamps which were used in mailing.

*600 Total copies of Proceedings printed.

Attendance

Not including thirty-four registrations from Purdue, one hundred and sixty-nine persons registered at the meetings. The latter figure includes sixty-six engineering educators representing forty-four institutions, forty-six highway engineers representing the U. S. Public Roads Administration and thirteen state highway departments, and fifty-seven other practicing engineers. In all, thirty-four states, the District of Columbia, three provinces in Canada, and New Zealand were represented. The wide geographical distribution of the members of the Conference is noteworthy, particularly the number of members from the Pacific coast states, the South, and the Southwest, as well as the northeastern states. The Proceedings have been purchased by engineering libraries and interested persons in all parts of this country, Canada, Australia, and England.

Meetings

In accordance with the plans for the conference, the meetings consisted almost entirely of discussions of the material contained in the Proceedings. In spite of the exigencies of national defense activities, the only speaker listed in the program for the meetings

who was unable to be present was Rear Admiral R. E. Bakenhus, U. S. Navy, retired. The formal discussions, listed in the program, occupied most of the time at each session of the conference. Active informal discussion from the floor supplemented the formal discussion at all sessions. No record was kept of the discussions presented at the meetings, but the following brief review presents the highlights of each session.

On Monday morning, following official welcomes to Purdue University, A. E. Cummings presented a graphic description of the extremely difficult soil conditions in Mexico City, where, in Mr. Cummings' words, settlements are so great and so rapid that "a level traverse cannot be closed if it takes longer than fifteen minutes!" On Monday afternoon the discussions centered on soil mechanics instruction. The importance of laboratory demonstrations and practice in soil mechanics courses was emphasized by many speakers, but a warning was given that soil mechanics is by no means exclusively a laboratory study. Interpretations of the returns on the questionnaires and the discussions on soil mechanics instruction as published in the Proceedings differed. Some members expressed very definitely the opinion that the time has now come when soil mechanics should be considered for a required basic course in civil engineering curricula. This opinion was not unanimous, but a majority seemed to feel that this stage of development for soil mechanics may be reached during the next few years.

The discussions of instruction in the applications of soil mechanics to foundation and highway engineering on Tuesday morning consisted largely of descriptions of the methods of instruction used at the various institutions. Inspection of laboratories followed this session. The afternoon session on Tuesday, at which Messrs. W. P. Creager, R. M. German, Jacob Feld, E. F. Preece, O. B. Lane, and others discussed field applications of soil mechanics by their several organizations, was of particular interest to the teachers of soil mechanics, in that the needs of the practicing engineer were presented from several points of view.

On Wednesday morning the major point of contention was the value or lack of value of mechanical analysis and grain size distribution in the identification and classification of soils. Opinion seemed about equally divided between the views that grain size distribution is related only remotely to most physical actions of soils and that it is a factor of considerable significance. Following this session, sampling demonstrations were held at the Purdue Joint Highway Research Project Test Roads and the test roads were inspected. The Wednesday afternoon session was devoted almost exclusively to discussion of the difficult problems of the shearing resistance of clays and testing methods for its determination. Con-

flicting points of view were presented by those who advocated uniform adoption of an arbitrary method of test in conjunction with extensive attempts at field correlation, and those who preferred to continue attempts to determine a true picture of the shearing resistance of clays in order that a more rigorous approach to field design problems may be made. The active discussion made clear the lack of definitive information on the shearing resistance of clays and the lack of adequate supporting evidence for existing hypotheses for the application of test results to field problems. This discussion was concluded with reluctance on the part of many members of the conference in order that departure might be made for the conference picnic at the Ross Surveying Camp of the Purdue School of Civil Engineering.

Thursday morning the discussion turned to earth pressure on walls, the effect of surcharges on earth pressure, and the stability of slopes. In addition to formal discussions by F. J. Crandell M. G. Spangler, W. S. Housel, and D. W. Taylor, O. J. Feld gave an instructive and amusing parable about earth pressure on sheet pile walls and Arthur Casagrande explained fallacies in the computation of "factors of safety" for earth dams and embankments. In the afternoon the discussion turned to stress distribution in soils under loaded areas, stress distribution around piles, pile driving formulae, and settlement problems with discussions by Messrs. Cummings, Feld, N. M. Newmark, D. M. Burmister, and others.

The Friday morning meetings were devoted to the discussion of soil problems in highway engineering, following very closely the material covered in the Proceedings with somewhat more emphasis on theoretical aspects of wheel load stress distribution and specific methods of subgrade treatment and stabilization. These topics could not be covered to the satisfaction of many members in this one morning, and about sixty conference members continued in a more detailed discussion on Friday afternoon.

The outstanding features of this conference were the consistently large attendance at every session, the active participation of many members in the general discussions, and the keen interest which members displayed at all times. The only lack felt in the meetings was for sufficient time for every person present to state to the group his views on the subjects discussed. The showings of motion pictures on Monday and Tuesday evenings were attended by a large proportion of the members of the conference and by members of families who accompanied some of the conference members. In addition to films prepared by various departments of Purdue University, interesting films were exhibited by the Chicago Department of Subways and Superhighways, C. A. Hogentogler of the Public Roads Administration, and T. B. Sturges of the Pennsylvania Drill-

ing Company. The laboratory demonstrations in the School of Civil Engineering and the field demonstration at the Joint Highway Research Project Test Roads also were attended by practically all members of the conference.

Conference Picnic

On Wednesday afternoon and evening, September 4, a picnic was held at the Ross Surveying Camp of Purdue University for conference members and their families. Outdoor sports were arranged by Professors W. I. Freel and G. E. Lommel of the School of Civil Engineering and A. K. Branham of the Joint Highway Research Project. The spirit of the conference is illustrated by the names "Triaxial Compression" and "Direct Shear" selected by the two baseball teams. These subjects had been actively discussed at the session immediately preceding the picnic. After a buffet supper, which was served in the camp mess hall, five graduate assistants of the Joint Highway Research Project, Messrs. R. F. Baker, R. E. Frost, W. J. Kay, G. W. McAlpin, and T. B. McClelland, entertained the one hundred and fifty-eight persons present with songs, some of which contained amusing references to the subjects of discussion and the members of the conference. The good natured fellowship engendered by this informal entertainment induced Messrs. R. F. Legget, University of Toronto, H. E. Winterkorn, University of Missouri, E. F. Preece, National Park Service, J. A. C. Callan, Georgia State Highway Department, and T. B. Sturges, Pennsylvania Drilling Company, to volunteer entertainment.

Conference Dinner

On Thursday evening, September 5, the members of the conference and guests met for an informal dinner in the Faculty Lounge of the Purdue Memorial Union. One hundred and sixty-four persons were seated at tables for four, six, and eight places. After the dinner, Dean A. A. Potter, of Purdue University, spoke briefly on the role that engineering schools will be expected to play in the national defense program. He also awarded miniature Purdue monograms to the members of the conference. A. Casagrande, Harvard University, then described briefly his summer work in Panama and in South America and showed colored motion pictures taken in Bogata, Columbia.

Housing and Meals

Members of the Conference and their families were housed in the hotel section of the Purdue Memorial Union, and male mem-

bers of the conference were also housed in the Cary Residence Halls for Men. Meals for the Conference group were served by the Purdue Memorial Union in a section of the west cafeteria set aside exclusively for this purpose. Comments by a number of members indicated that the living accommodations arranged by the University were most satisfactory.

Application of Soil Mechanics to Highway Engineering

The sessions devoted to the applications of soil mechanics to highway engineering were held on Friday, September 6. This portion of the program and the corresponding section of the Proceedings were arranged by Professor K. B. Woods, assistant director of the Purdue Joint Highway Research Project. The attendance at the Friday morning meeting, which was the last formal session of the Conference, was fully as large as that at any of the preceding meetings. By popular request, the discussion of this subject was continued on Friday afternoon.

Value of the Conference to the Society for the Promotion of Engineering Education

This conference was organized as a result of persistent requests on the part of engineering teachers. The Proceedings of the conference represent an attempt to collect opinions about soil mechanics instruction and to summarize instructional methods now being used. In addition, the Proceedings contain papers on various important problems in soil mechanics and extensive lists of references on some of these problems. The object of the Proceedings was to provide organized source material for new teachers in the subject. The meetings of the conference followed the same general plan as the Proceedings, emphasizing both instructional methods and the content of soil mechanics. The interests of the members who attended the meetings varied. Some wanted to know what soil mechanics was all about and whether or not it should be taught at their institutions. Others were interested in teaching methods and programs. Still others were interested primarily in some of the specific problems discussed. And finally some of the practicing engineers in attendance desired only to pick up some practical methods which they could apply in their work in the field. The conference could not satisfy adequately such heterogeneous wants. The members at the meetings did not adopt definite recommendations in regard to soil mechanics instruction. Rather each member formed some conclusions of his own from the discussions. No attempt was made to present in the Proceedings hitherto unknown solutions for im-

portant problems. None the less, the Proceedings have collected valuable information on the present status of soil mechanics and soil mechanics instruction. The meetings have demonstrated an awakened interest in the subject in many of our engineering schools and have indicated a trend toward the introduction of soil mechanics into the required civil engineering curricula as a basic subject of engineering and economic importance. Through this conference the Society for the Promotion of Engineering Education has taken one more step toward the furtherance of scientific analysis of soil and foundation problems in our engineering curricula and toward unification of effort in soil mechanics instruction at the several institutions.

ACKNOWLEDGMENTS

The Committee on Soil Mechanics and Foundations is grateful to Professors M. W. Furr, Chairman, and E. E. Bauer, Editor, of the Civil Engineering Division, Society for the Promotion of Engineering Education, for enthusiastic coöperation. The publication of the Proceedings by the loan of Purdue University funds and the meetings at Purdue were made possible by the coöperation of Professor R. B. Wiley, Head of the School of Civil Engineering, Dean A. A. Potter, of the Schools of Engineering, and Professor W. A. Knapp, in charge of the Engineering Extension Department. The assistance of Professor K. B. Woods and the staff of the Purdue Joint Highway Research Project was invaluable in the production of the Proceedings and the conduct of the conference.

Respectfully submitted by

P. C. RUTLEDGE, *Chairman*
For Committee VII on Soil Mechanics and Foundations of the Civil Engineering Division

PROGRAMS FOR TEACHERS OF ENGLISH AND SPEECH

PROGRAM FOR THE ENGLISH SECTION, UNIVERSITY OF MICHIGAN

Tues., June 24—2:00 P.M. ....., presiding.
The Laboratory Method of Teaching Freshman English—R. D. Scott, University of Nebraska.
Discussion—C. A. Brown, General Motors Institute, H. L. Creek, Purdue University.

Wed., June 25—2:00 P.M.—Homer N. Nugent, presiding.
Topic—English and Defense.
Writing and Defense—Jay Reid Gould, Rensselaer Polytechnic Institute.
Speech and Defense—Wilfred M. Senseman, University of Michigan.
Specialized Services—Theodore Smith, Massachusetts Institute of Technology.

Wed., June 25—6:30—Dinner Meeting ....., presiding.
(Speaker not yet determined.)

Summer Conference for Teachers of English and Speech in Technical Schools

Immediately following the annual meeting of the Society for the Promotion of Engineering Education, the University of Michigan in coöperation with the Society will conduct a Conference for Teachers of English and Speech in Technical Schools from June 30 through July 18. It is proposed to discuss the special problems relating to the training of students and of teachers of composition, speech, and literature. The emphasis recently put on these elements of training for professional work indicates the importance and significance of such a conference.

The University of Michigan provides a very fine setting for the conference. During the coming summer session, background courses will be given in English, economics, sociology, philosophy, government, and in other fields where the teachers of technical students can, if they desire, enlarge their fund of information. Of further interest is the series of lectures which will be given by renowned speakers on the general topic, "Public Policy in a World at War." These lectures will be open to registrants.

A numbers of teachers of engineering students in institutions other than the University of Michigan will aid in the work. Professor George Summey, Jr., of the Agricultural and Mechanical College of Texas will have charge of the section on composition. Professor Joseph L. Vaughan of the School of English, Department of Engineering, University of Viriginia, will supervise the section on literature. Professor Carl G. Brandt of the Department of English, College of Engineering, University of Michigan, will direct the section on speech. Other leaders in the several fields will help conduct the courses.

To provide living quarters for those who attend the conference, a unit in one of the dormitories will be set aside. The registration fee for the conference will be $10.00. This amount, however, will not be assessed against those enrolled in the regular Summer Session. Specific information regarding living expenses will be contained in a bulletin to be issued later. *For any information that you may desire, write to Professor J. E. Thornton, Chairman of the Committee on Arrangements, University of Michigan, College of Engineering, Department of English, Ann Arbor, Michigan.*

PROGRAM FOR SUMMER CONFERENCE FOR TEACHERS OF ENGLISH AND SPEECH IN TECHNICAL SCHOOLS

First Week

Literature in the Engineering School
June 30–July 4

June 30

10–12 The Literature Program in the Engineering School from the Administrator's Point of View—What the President or Dean Expects the Program in Literature to Accomplish.
E. C. Elliott, President of Purdue University.
E. S. Burdell, Director, Cooper Union.
Discussion.

2–4 Objectives and Problems of the Literature Program from a Departmental Point of View.
Howard R. Bartlett, Head of the Department of English and History, Massachusetts Institute of Technology.
W. Otto Birk, Head of the Department of English, College of Engineering, University of Colorado.
W. S. Lynch, Associate Professor in Charge of Humanities, Cooper Union.
Discussion.

July 1

10–12 The Relation of the Engineering Student to Literature.
C. K. Judy, Head of the Department of English, California Institute of Technology.
Discussion.

2–4 A Teacher of English in an Engineering College Asks Some Questions—A Consideration of Different Types of Courses, etc.
Ivan Henry Walton, Professor of English, College of Engineering, University of Michigan.
H. J. Muller, Assistant Professor of English, Purdue University.

July 2

10–12 Development of Interest in Literature.
J. L. Vaughan, Head of the School of English, Department of Engineering, University of Virginia.
On the Panel:
C. K. Judy, Head of the Department of English, California Institute of Technology.
C. M. Rowe, Head of the Department of English, South Dakota State School of Mines.
C. J. Adams, Head of the Department of English, Worcester Polytechnic Institute.

2–4 On Teaching Literature to Engineering Students.
R. L. Shurter, Assistant Professor of English, Case School of Applied Science—"Comments on Teaching the Essay, the Biography and the Novel to Engineering Students."
Carl Edwin Burkland, Associate Professor of English, College of Engineering, University of Michigan—"Comments on Teaching Poetry to Engineering Students."
S. M. Tucker, Head of the Department of English, Brooklyn Polytechnic Institute—"Comments on Teaching Drama to Engineering Students."

July 3

10–12 What Engineering Students Read.
Atwood H. Townsend, Assistant Professor of English, College of Engineering, New York University—"Books that Engineering Students Enjoy Reading."
On the Panel:
Wilson R. Dumble, Instructor in English, Ohio State University.

2–4 Stimulating Engineering Students to Read.

Amy V. Hall, Assistant Professor of English, University of Washington—"Techniques in the English Course that May Encourage Students to Read Widely."

W. Paul Jones, Professor of English, Iowa State College—"Extra Curricula Techniques that Encourage Students to Read Widely."

On the Panel:

Homer Nugent, Professor of English, Rensselaer Polytechnic Institute.

Sada A. Harbarger, Associate Professor of English, Ohio State University.

C. W. Park, Professor of English, University of Cincinnati.

Discussion.

July 4

10–12 The Post Graduate Engineering Student Does Some Reading.

A. F. Andrews, Technical Library Staff, Tennessee Valley Authority.

Discussion.

2–4 Summary of the Findings of the Group Examining the Problem of Teaching Literature in the Engineering School.

J. L. Vaughan, Head of the School of English, Department of Engineering, University of Virginia.

Second Week

English Composition in the Engineering School

July 7–11

July 7

10–12 Scholarship That Works.

George Summey, Jr., Head of the Department of English, Agricultural and Mechanical College of Texas.

Discussion: H. L. Creek, Purdue University, L. I. Bredvold, University of Michigan.

2–4 The Background of the Teacher of English Composition in the Engineering School.

Warner Rice, University of Michigan.

Howard R. Bartlett, Massachusetts Institute of Technology.
Stewart S. Morgan, Agricultural and Mechanical College of Texas.

July 8

10–12 Normal Written Style Today.
George Summey, Jr.
Discussion: J. L. Vaughan, University of Virginia, Carl G. Brandt, University of Michigan.

2–4 Discussion of Problems in English Composition.
The Reading Problem.
S. H. Peterson, Oregon State College.
George S. Wykoff, Purdue University.
Orientation vs. Composition.
W. Earl Britton, University of Michigan.

July 9

10–12 Levels of Good Language.
George Summey, Jr.
Discussion: Karl O. Thompson, Case School of Applied Science, J. E. Thornton, University of Michigan.

2–4 What Is Good English?
Albert H. Marckwardt, University of Michigan, H. R. Young, Case School of Applied Science.

July 10

10–12 Improving Vocabularies.
George Summey, Jr.
Discussion: T. A. Knott, University of Michigan, E. A. Tenny, Cornell University.

2–4 Class Levels in Current American English.
Charles Carpenter Fries, University of Michigan.
Discussion: W. Otto Birk, University of Colorado.

July 11

10–12 Technical Writing.
(Speaker not yet determined.) Detroit.
Discussion: C. A. Brown, General Motors Institute of Technology, A. M. Fountain, North Carolina State College of Agriculture and Engineering, J. E. Thornton, University of Michigan.

2–4 Technical Bibliography.
Edwin C. McClintock, Jr., University of Virginia.
Discussion: (Speaker not yet determined), University of Michigan.

July 14–July 19

Third Week

July 14

10–12 Problems of Teachers of Public Speaking.
W. Hayes Yeager, President of the National Association of Teachers of Speech and Professor of Public Speaking, The George Washington University.
2–4 Round Table Discussion led by Professor Yeager.

July 15

10–12 Teaching Speech Delivery.
Gail E. Densmore, Chairman of the Department of Speech of the University of Michigan and former Executive Secretary of the National Association of Teachers of Speech.
2–4 Demonstration Class conducted by Professor Densmore and followed by discussion.

July 16

10–12 Teaching Speech Composition.
Alan H. Monroe, former President of the National Association of Teachers of Speech and Chairman of the Speech Section, Department of English and Speech, Purdue University.
2–4 Demonstration Class conducted by Professor Densmore with composition criticism by Professor Monroe followed by discussion.

July 17

10–12 Improvement of the Voice.
Henry M. Moser, Member of the National Council for Speech Correction and member of the staff of the Institute for Human Adjustment, University of Michigan.
2–4 Round Table Discussion led by Dr. Moser. Panel to be announced.

July 18

10–12 Summary of the week's proceedings and talk on "The Objectives of Public Speaking in Colleges of Engineering."

Carl G. Brandt, Chairman of the Department of English in the College of Engineering, University of Michigan.

Summary of the proceedings of the Conference.

J. L. Vaughan, George Summey, Jr., Carl G. Brandt.

THE T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE
DIVISION OF ENGINEERING DRAWING

B. M. GREEN, *Editor*, Stanford University

TENTATIVE PROGRAM OF THE DRAWING DIVISION AT ANN ARBOR

(The list of speakers is not yet complete)

Monday, June 23.

2:00 P.M., First Conference Session.

1. Drawing in the Defense Industries.
2. Engineering Defense Training Courses in Drawing—A Panel Discussion.
   - *a.* Plan and Purpose of the Courses.
   - *b.* Previous Training and Selection of Students.
   - *c.* Objectives and Content of Courses.
   - *d.* Relationship to Regular College Courses.
3. Training in Drawing for the Long Pull.

Tuesday, June 24.

12:00 Noon, Luncheon.

1. Report on National Survey.
2. Report of Nominating Committee.
3. Election of Officers.

2:00 P.M., Second Conference Session.

1. Drawing Technology in the Aircraft Industry.
2. Efficient use of Time in the Classroom and Laboratory—A Panel Discussion.
   - *a.* Classroom Efficiency.
   - *b.* Teaching Aids.
   - *c.* Laboratory Supplies and Equipment.
   - *d.* Student Efficiency on the Drawing Board.
3. Nomography, an Advanced Course in the Graphics Department.
4. Reports of Standing Committees.
   - *a.* Graphic Talents and Visualization Tests.
   - *b.* National Drawing Competition.
   - *c.* Historical Research.
   - *d.* Committee of Applied Descriptive Geometry.
   - *e.* Drawing Instruments.
   - *f.* Drafting Room Equipment and Lighting.
   - *g.* Drafting Standards.

7:00 P.M., Drawing Division Dinner.

1. Report of Judges on Drawing Competition.
2. Address. Speaker and Subject to be announced.

YOU AND RESEARCH *

By T. A. BOYD

Research Laboratories Division, General Motors Corporation, Detroit

Most speakers talk shop, I suppose. This is because their particular line of shop talk concerns the thing to which their special information—if any—relates. And so, with your permission, I am going to talk shop too. As a research man, I am going to talk about industrial research and the relationship of you as teachers of engineering to it.

There are of course easier things to do than to make such a subject entertaining to you, and I feel that any address ought to be entertaining enough to be interesting. Horace Greeley defined "success" in a lecture as "where more folks stay in than go out." It is because I hope to do much better than that that my task is a little hard.

Industrial research is an adjunct to modern industry which employs about as many persons as the cleaning and dyeing business, or about twice as many as are engaged in making motion pictures. The number of workers in industrial research laboratories today is given as between 40,000 and 50,000. And, according to the figures of the National Research Council, about 10,000 of these are engineers.

But, just as in making movies, everyone can not be a star, or even an actor, so in a research laboratory there must be workers of many kinds. You have heard that "It takes nine tailors to make a man." (But of course none of us nowadays can afford to hire all nine of the tailors.) Just so to do a good job of industrial research takes men of many talents, only a limited portion of whom are technical men or trained research workers. Needed in research also are mechanics, instrument makers, pattern makers, draughtsmen, engine men, accountants, stenographers, and even errand boys.

I happen to know a trained engineer who has made an invaluable place for himself as a procurer of supplies for a research laboratory. That is far from being an easy job, for an infinite variety of materials is wanted by a research laboratory, many of which can not be had anywhere. One of the difficulties in industrial research,

* Presented at the meeting of the Illinois–Indiana Section, S. P. E. E., Notre Dame University, April 20, 1940.

incidentally, is that the worker calls on suppliers to furnish unusual things, but he wants so few of them that there is no profit in it for the one who fills his needs.

There is a story about a salesman for an aluminum company who received a hurry-up call from one of his customers. This customer must have been an experimenter of some kind, for what he wanted, and wanted quickly, was just the kind of thing research men call for. He wanted a sheet of aluminum foil, five or six inches square but only a third of a thousandth of an inch thick. The salesman was stumped for an instant. Then he asked: "Got a nickel?"

"Sure."

"Gimme—and I'll be back in a minute."

He returned from the drug store across the street with a 5-cent chocolate bar, and handed it to the customer. Removing the wrapper, the customer got his aluminum foil, and then the two of them ate the chocolate.

This business of industrial research, in which ten thousand or so engineers are now engaged, is really quite a new thing. As an adjunct to industry it has come into existence almost altogether since 1900. There were, of course, a few industrial research laboratories prior to 1900. But they were very few. Edison's laboratory out at Menlo Park was one of these, and one which made important contributions.

Edison's efforts, incidentally, were sometimes reported in the press of the time about as inaccurately as are some research endeavors today. One of these stories was written by Eli Perkins, the Will Rogers of that day. "When I called on Professor Edison at Menlo Park," wrote Perkins, "he was engaged in a new experiment. . . . The Professor tried . . . concentrating water to be used in fire engines in case of drought. . . . Twelve barrels of water were evaporated down to a spoonful, and this was sealed in a small phial, to be diluted and used to put out fires in case of drought or where no water can be had."

But the real period of the industrial research laboratory began in 1900 when Willis R. Whitney started doing research in a corner of one of the buildings of the General Electric Company out in Schenectady. The du Pont Company began organized research in 1902. Frank B. Jewett, head of the great Bell Telephone Laboratories, started his career of research in the telephone business in 1904. The central research laboratory of General Motors was first organized in 1910. But in reality most of our industrial research laboratories have been organized since the World War, and according to the National Research Council there are now something over 2,000 of them.

There is one thing about research in industry which it is particularly important to note. This is that in industrial research it is necessary to go much further than merely to find something new, as the man who calls himself a pure scientist does. A very long and difficult way has to be traversed from the mere discovery of a new principle to the point at which it can be made of practical service to people. The industrial research laboratory, you see, has to have something more than mere "finder-outers." It must have "getter-doners" too, and these latter are very likely to be engineers. It is in the matter of making new ideas useful to people—in putting research to work—that the industrial research laboratory and the engineers in it make their great contribution to society.

The necessity of a long period of development in making new ideas practical is not always fully understood by the non-industrial research worker, nor by some business men—not to say by most free-lance inventors as well. "It is my opinion," said Charles F. Kettering, "that if we left it to a group of business men to raise human children in the same way as they try to raise business children, a child nine months old would have to be earning its own living."

Speaking once to a group of physicists about research in industry, Mr. Kettering said this also: "A physicist within a university has only two factors in his problem to deal with. They are the material and energy relationships. But when you go outside into an industry you have four factors. You have the material and energy relationships the same way, but you have economics and psychology added to them. Now I don't know if the complications go up as the square or the cube of the factors involved, but when you put those other two dimensions of psychology and economics into the thing it does complicate it somewhat. It isn't the fact that the thing will work that is important; it is whether the fellow you do it for likes it and whether he is willing to pay for it after it is done."

Kipling seems to have had some understanding of the difficulties and complications of making new things practical. For in a letter which he wrote more than 30 years ago to one of his friends about the automobile he said: "Any fool can invent anything as any fool can wait to buy the invention when it is thoroughly perfected; but the men to reverence, to admire, to write odes and erect statues to are those . . . who chase the inchoate idea to fixity up and down the King's highway." Chasing half-baked ideas to fixity or practicality is one of the most important parts for which the engineer in industry has to be trained. Incidentally, Kipling owed some of his own great success as a writer to the fact that he himself made use on occasion of the fact-finding method of the research labora-

tory. Kipling said that he early observed that one way to get the interest of readers was to write his stories in words with an appropriate atmosphere, or words which, as Kipling put it, had "taste and, if need were, smell." And that is a thing at which Kipling became a master. But he did it, as he himself said, not without the aid of much literary research, or much searching in unusual places.

In his autobiography, Kipling tells the story of how he got color and authenticity for his great story, *Captains Courageous.* In company with Dr. Conland, a friend of his and a former cod fisherman, Kipling spent days and days around the old T-wharf of Boston Harbor, boarding craft of every kind, riding tugs and old schooners, collecting ancient charts and compasses, and digging up the names of old schooners and old tales of the sea. It was Kipling's rule, as he himself put it, to "Take nothing for granted if you can check it." One result of Kipling's pains was to make his works so popular that his publishers had to pay him a shilling a word. You may have heard the story about the joking students who, having understood that Kipling got a shilling a word, wired him a shilling, saying, "Please send us one of your words." And Kipling answered, "Thanks."

Nearly a hundred years ago, Charles Goodyear said this about what it takes to make a new idea practically useful: "It is a mistaken notion that an invention consists in the first vague idea of it. It takes far more than that to entitle one to the merit of an invention, for, between the bare conception of an idea, and the demonstration of the practicality and utility of the thing conceived, there is always a vast amount of labor to be performed, time and money to be spent, and innumerable difficulties and prejudices to be encountered before the work is accomplished."

From five to eight years has been given as the *usual* length of time required to develop a new discovery to the stage of commercial practicality. And usually the process can not be hurried much. The sponsor of pioneering research must therefore have the qualities of the diplomat, as once defined by Sir Esme Howard in these words: "The great art of diplomacy is patience, patience, and again patience." There is, you see, no such thing in industrial research as a *blitzkrieg* or lightning campaign.

Just the other day I heard about an important executive in industry—and this man was an engineer too before he became a vice-president—who complained to the head of a research laboratory about the difficulties of getting new things into production. "Every time we try anything new we get into so much trouble," he said, "that I have begun to believe we should turn thumbs down on all these new things. The production men can not predict what it will cost to manufacture, and there is just one difficulty and

costly delay after another." But that was his attitude as a business executive. As an engineer he should have learned to have a different viewpoint.

Years ago when Mr. Kettering was doing research for the National Cash Register Company, the president of the company, John H. Patterson, came to him one day to inquire how soon a certain development on which he had then been engaged for some time would be completed.

"In about a year," Mr. Kettering estimated.

"All right, then, I want you to double your force and finish it up in six months."

"I am afraid that can't be done, Mr. Patterson. It will probably take just about a year yet to finish the job."

"Do you mean to tell me, sir, that if you had twice as many men you could not do double the work on this project?"

"Maybe I can answer your question best by asking another, Mr. Patterson. Do you think that if two hens were put on the nest a setting of eggs could be hatched out in less time than three weeks?"

In the case of tetraethyl lead as an antiknock agent, the biggest development with which I myself have been associated, it took ten years of constant effort to bring it to commercial success, and the endeavor was more than three million dollars in the red before it showed any profit at all. This is why Sir J. J. Thompson has said that the most useful kind of balance for a research laboratory to have is a balance at the bank.

You have heard the common saying that nearly all of the really fundamental discoveries have been made by the pure science investigator, working usually in a university or similar institution. But, although the pure science worker has, to be sure, made his full share of such contributions, it would be easy to show that he has not made all of them by any means. The truth is that fundamental discoveries come from so many sources that it is not always easy to tell just to whom it is that thanks for them are due. And so we can sometimes do no better in the way of allocating thanks than did the new Chinese student up at the University of Michigan who attended one of President Ruthven's teas. He was still a little weak on his English. So, before going, he memorized some phrases from an etiquette book to use on occasion. And, when a cup of tea was handed to him, he solemnly responded: "Thank you, sir or madam, as the case may be."

Industry in the United States is expending about $200,000,000 a year on industrial research. In addition, the Federal government spends about $60,000,000 for research of one kind or another. The states also spend money on research, largely through state-supported educational institutions. In round figures, about one cent out of

each dollar grossed by manufacturing and agriculture in the United States is spent on research. And that perhaps gives just about as good a measure of the scope of industrial research as an enterprise as can well be given. This is the amount that on the average is being invested in the future, or to keep industry moving up the road of progress. Whether it is enough or not depends upon one's viewpoint perhaps. But anyway, by and large, the slope of the curve of progress is surely not too steep.

The automobile is, incidentally, one thing that benefits from research of a very wide scope. In addition to all the immense amount of research that is done within the automobile industry proper, much of that done by the steel industry, the rubber industry, the chemical industry, the petroleum industry, and others serves to advance the automobile. Of the about 2000 industrial research laboratories in the United States, around 500 or 25 per cent are either those within the automobile industry proper or those maintained by makers of materials used in or by the motor car. In reality all the many workers in these laboratories are thus in the automobile business to a degree, even though they may not all realize it. Of the technical workers in the research laboratories of the automobile industry proper 60 per cent are engineers.

This, then, is what the business of industrial research is like. It is a business which employs ten thousand engineers and which absorbs a thousand or more new engineers each year. The latter number is only a guess, of course, made on the basis that the replacement rate is 10 per cent per year.

What Employers Want

And just what does the research director demand in the new men he employs? That question is, to be sure, a hard one to answer. It is such a difficult one, in fact, that in trying to answer it I am going to be like Alice in Wonderland when she said that she could explain the thing she was talking about better if only she understood it herself.

The question about what employers want is one to which there is really no single answer. The reason is that the demands of employers in industry differ considerably from one employer to another, depending upon the personal characteristics of the employer and upon the particular conditions which he has to meet. That is perhaps a lucky thing for the college and for the college-trained man, because college men have surely not all been poured into one common mold.

In blood transfusion it is essential that the blood of the donor be of the same type as that of the patient. Just so the employer,

when infusing new blood into his organization, looks for men with those qualities which suit his own particular temperament, or which he thinks will fit into his organization to advantage. Paul de Kruif has told how, when Ronald Ross in India was looking for an assistant to help him in his search for the malaria microbe, he hired Mahomed Bux, because, said Ross, "he had the appearance of a scoundrel, and scoundrels are much more likely to be intelligent." But, at least among research directors, Ross's rule is not looked upon with favor. Directors of research want men with intelligence, to be sure, but they want them as well to be intellectually honest in the strictest sense of the word. Besides that, they want the men they employ to have many other qualities. Some of these may be enumerated; but in listening to them it should be kept in mind that there is a difference from employer to employer in the relative weight given to each item named.

Employers in research laboratories want the college-trained men to have knowledge, of course. But, they do not care so much about mere encyclopedic knowledge, for that is usually not worth much. A good encyclopedia can be bought for a hundred dollars, you know. What they do care about is knowledge of the fundamental principles of essential subjects and of how to muster the scattered information which is available; and then—and most important of all—how to bring it to bear upon the problem in hand. This demands the ability to think independently, which faculty is another one of those that research directors want the college-trained man to have.

The engineering school is a particularly good place both to get knowledge and the ability to think. It is however a matter of experience that not every one who goes through the university gets out of it what he is supposed to. President Lowell said, "No wonder there is so much knowledge in colleges. The freshmen always bring in a lot, and the seniors never take any away with them."

Employers in research laboratories particularly want the man who is good at getting *new* knowledge, which means that he must know and be able to use the so-called scientific method, which is the basis of all research. And so they want him to be a good experimenter and a minute and accurate observer. They want, if possible, to avoid the fellow who reaches conclusions from insubstantial evidence. The research director wants the man who has imagination, resourcefulness, and initiative—who is something of a self-starter, and who does not depend upon the boss to furnish all the ideas, for the boss's ideas are usually too limited anyway. And, along with initiative, he wants the men to have persistence, or that form of stick-to-it-iveness which someone has called "finishi-

tive." He wants the fellow who looks for reasons why a thing *can* be done rather than for reasons why it can *not* be done. He does not want the man, of which there are altogether too many, who considers present knowledge as a preserve with a fence around it—as a preserve that it is not worth while to go outside of at all. With such a handicap no one ever finds anything new, of course. If a fellow is to be a success as an engineer or a research worker, he can not afford to believe, as so many people seem to nowadays, that everything has been done—that the world is finished, and that there are no more frontiers. For any of your students who may be unlucky enough to have accepted this fallacy you will surely be doing a great service if you can get them to follow the example of the atheist. He *quit* being an atheist because, as he said, there's no future to it.

The research director wants the man with enthusiasm for his job. He wants him to have a measure of versatility, or ability to adapt himself to the investigation of different kinds of problems, and usually he does not like for him to have made up his mind that he can work only in one highly restricted field. He wants him to be able to coöperate with others, to get along well with whatever kind of workers he may have to come in contact with, and to make a good impression wherever he goes. Prima donnas are usually not very useful in an organized research laboratory, nor anywhere else in industry. And then he wants him to have good health and good sense—that sort of good sound sense which by some is called "common sense" and by others "horse sense."

The research director wants particularly the man who can write reports that are accurate, easy to read, and readily understood. A young fellow by the name of Stevenson once wrote an article on the "Thermal Influence of Forests." "It was rather a dull paper," said Prof. D. W. Thompson. "It made a good show of meteorological learning. . . . Its style was technical and scientific." But that same Stevenson did much better later on when he wrote a book called *Treasure Island*. Surely if he had tried he could have put into that early article on forests less of technicality and dullness and more of the simplicity and attractiveness so marked in his later work.

Distinctly worth while mentioning also is the important fact that not all the qualities enumerated here as desirable are acquired solely in college or university, if indeed some of them are got there at all. A few, such as initiative, "finishitive," imagination, intellectual honesty, good health, and ability to get along with people, are often acquired in the home or in the school of experience, and often very early in life—or are they sometimes just gifts of the gods?

"It is the task of the university," said Frank B. Jewett, head of the great Bell Telephone Laboratories, "to sift the raw material that comes to it, to encourage the talented student, to drive home the fundamentals, to create the proper outlook toward the field of science." For that purpose the ordinary orthodox subjects of study are all right, and particularly those which deal in the fundamentals of science and engineering. It distinctly does not demand that a man be specifically trained in the details of any one particular business. That may even be a handicap, rather than a help.

A great deal has been said and written about how to apply for a job, how to write letters of application, how to conduct one's self at personal interviews, etc. And all that is important—it is *very, very* important. But, students in engineering colleges should know about another thing which, for any one who expects to go into engineering or industrial research is even more important still. And that is to establish with you men who are his teachers in the university a reputation for having a good measure of the qualities enumerated during the past few minutes. And this means that in some way he must actually acquire the qualities named, such as intellectual honesty, initiative, enthusiasm, versatility, and knowledge of the important fundamentals in science and engineering. The reason why this is of paramount importance in the case of the man going out of school into his first job is of course that any prospective employer will surely ask the advice of you men in the college, and your opinions are always given large weight.

Dr. Jewett, already referred to, has given three rules for finding new members of a research staff. The first of these rules is that the search should be made among *young* men; and engineering students are all young, of course. The second rule is that the best places to search are the universities and schools of science; and that naturally includes the colleges of engineering. But the third and most important of the three rules is that the judgment of those men in the university who have had first-hand opportunity to know and appraise the men under consideration for considerable lengths of time should be given large weight. Employers *do* give so much weight to such advice that it is surely worth any student's while to establish a good reputation with the sources of the advice. And should he not be told in advance how important that is going to be?

The Scientific Method More Useful Than Its Products

But, after all, this demand of the research director that the engineers he employs be more than mere formula users—or men who think, as some seem to do, that their job is only to apply existing information—is really one that all the engineers in industry ought

to be able to meet. To this end it is believed that every student of engineering should be taught, when tackling his problems, to make use of the fact-finding and fact-facing principles of research—the so-called scientific method—and no doubt that is being done in most cases. But the engineering student needs to have concrete instruction in just what the scientific method is, and in how to use it himself in a practical way. It would appear that he ought also to be given enough actual practice in getting new knowledge by the experimental method to give him a firsthand appreciation of the usefulness of the research technique and a reasonable degree of facility in using it, as well as in interpreting and evaluating the results got by it. This would seem to demand that his laboratory work should extend somewhat beyond the mere testing of representative engineering equipment.

There are chemical research laboratories nowadays that have quit hiring any but Ph.D. men. And why have they done that? Surely not alone because Ph.D. men even know very much about the pioneering problems in chemistry that they are going to be asked to help solve. Of course not; but chiefly because the Ph.D. man has had training and some small experiences in actually doing research under the guidance of a teacher who knows how to go about the job.

So far as engineers and people in general are concerned, it is believed that the greatest contribution which research has made and can make does not lie in the concrete products of the research laboratory, marvelous as they sometimes are. It lies rather in the *method* by which research has made these contributions. By comparison with the possible usefulness to the engineer and to people in general of the research method itself, some of the tangible things it has yielded are mere gadgets. The method of the research laboratory, which consists in finding the facts first and then facing 'em, can be and should be applied everywhere, even in everyday affairs. The old method of hunch or intuition will not serve. Even woman's intuition has been defined merely as something that tells her she's right, whether she is or not.

Paul Farnsworth of Stanford University recently used the research technique to check up on the claim of astrologists that the stars influence the abilities of people. That, as you know, is a thing which is still believed by a large section of society. The horoscope says, for instance, that persons born under the seventh sign of the zodiac should have musical ability. So Dr. Farnsworth did the straight-forward simple thing of looking up the birth dates of about 1,500 musicians. What he found by this simple research was that fewer of these musicians were born under the seventh sign than under any other of the twelve, except one. Thus in

picking the sign for musicians the astrologists could have made ten better choices—or should I say guesses—than they did.

There has always been a common opinion that the beautiful and popular girl is usually dumb—or at least not altogether as bright as other people. That is an idea which until recently no one had ever taken the trouble to check up on by the experimental method. But recently Prof. J. E. Janney—who happens to be a teacher in a women's college, and so has plenty of subjects to work on—put this common belief to the test of experiment. His results, as expressed in the vernacular, knocked into a cocked hat the old idea that the pretty girl is always dumb.

In 1937 I heard one of the most prominent attorneys in Detroit telling an assemblage that improved methods of making cars had greatly reduced the number of workers needed per car since 1929. But the truth is that *more* men—15 per cent more men—worked in automobile factories in 1937 than in 1929. And this was so in spite of the fact that fewer cars were made then than in 1929. If only the attorney had had enough of the research spirit and had taken the trouble to check up first on the figures of the U. S. Bureau of Labor Statistics, instead of depending upon hearsay, he would not have made that mistake.

The research method can be as useful to the business man as to the engineer. "It is just as important," says Alfred P. Sloan, Jr., "to apply research to all the functional activities of business as it is to the technological phases of the enterprise." Truth to tell, business has always been run too largely on hunch and not enough on cold facts.

But a great many engineers become business men too, and Mr. Sloan is one of them. Some years ago Robert H. Spahr presented to your Society a report of a survey of the training of officers of companies in American industry. His figures showed that of the 235 college-trained presidents in leading American industries, 151 had been trained in engineering or technical schools, and only 84 in colleges of all other types. In consideration of the fact that the number of graduates of other types of colleges is several times that of the engineering schools, these figures suggest that a man trained in engineering is 10 to 20 times as likely to become president of an important enterprise as is the man trained in a college of another type. Now, while the reason for this is not certainly apparent, it is perhaps permissible to suggest that one of the principal differences between the graduate of the engineering college and other colleges by and large is that the engineering college tries to train its students to find the facts first, and then to decide the question on the basis of those facts, without prejudice or bias.

It is because engineers and men of science have—or should have

—been trained to find the facts and then face 'em that they are usually more honest than people in general. And by and large engineers and scientists *are* more honest. But, the honesty of people in general being what it is, this comparison does not to be sure give the engineer such a high average in honesty that he can always be trusted implicitly in everything.

Now what has just been said about the usefulness of the research method in engineering and even in everyday affairs may to some of you seem altogether too obvious to require statement. Aren't all engineers taught to use the facts? Yes; but nevertheless it is so that the scientific method is not being used nearly enough even by engineers. Men of science themselves do not always take the scientific habit of mind home with them when they leave the laboratory in the evening. "Fact finding," said Owen D. Young recently, "is one of the least developed of American national resources."

With most people, even those of us who are engineers, the situation is often too well expressed by something General Robert E. Lee once wrote in a letter to his son, Captain Robert E. Lee, Jr. "The girls are well," wrote General Lee, "and have as many opinions with as few facts as ever." But surely the engineer is one person of whom this ought not to be so, either in his professional life or in his everyday life. And that is the central theme of this final section of my simple story about research and your relationship to it as teachers of engineering.

FINAL REPORT COMMITTEE ON ENGINEERING RESEARCH 1939–1940

WHITHER GRADUATE RESEARCH? . . . GRADUATE ENGINEERING THESES SUBMITTED IN AMERICAN SCHOOLS IN 1939

CONCLUSION

Electrical Engineering

Alabama Polytechnic Institute

A study of transient currents in electric circuits, George Thornton Nelson, M.E.E., May 1939.

Advantages of central station service for industrial operations, as compared with isolated power. Roy Willis Wages, E.E., May 1939.

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An electro-mechanical solution of simultaneous linear equations, Clarence Huetten, M.S. in E.E., June 1939.

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Design, construction and test of a Q-meter for use at ultra-high frequencies, Anthony B. Giordano, M.E.E., June 1939.

Circuit phenomena in double energy circuits including an electric arc as an element, Ingolf B. Johnson, M.E.E., June 1939.

Investigation of common errors found in insertion loss measuring circuits, Gregory N. Slezskinsky, M.E.E., June 1939.

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The impulse characteristics of oil gaps from the standpoint of insulation, coordination, Gilbert Donald McCann, Ph.D. (E.E.), June 1939.

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An analytical and experimental study of superregeneration, Joseph Berzowski Berkley, M.S. in E.E., May 1939.

Studies of circuits containing thyrite as a nonlinear resistance element, Seigmund Chambre, M.S. in E.E., May 1939.

Feedback amplifier tube, Alex de Bretteville, Jr., M.S. in E.E., May 1939.

An impedance bridge for measurements at a frequency of 200 megacycles, William Ryland Hill, Jr., M.S. in E.E., May 1939.

Analytical approach to the investigation of the reflection and transmission of light in fog, Low Kee Lee, M.S. in E.E., May 1939.

Experimental investigations of light transmission and reflection in fog, Herman Thal-Larsen, M.S. in E.E., May 1939.

An experimental investigation of the effect of mountains in the production of multiple beams from radio beacon transmitters, Delos Edwin Wait, M.S. in E.E., May 1939.

Ferro-resonant non-linear control circuits, William T. Thomson, Ph.D. (E.E.).

Some theoretical aspects of the effect of topography in the production of multiple beams from radio beacon transmitters, Edward Colston Dyer, M.S. in E.E., September 1939.

The generation of square-wave voltages at high frequencies, Willard Henry Fenn, M.S. in E.E., Dec. 1939.

Developing and testing of an electronic phasemeter, Walter Edward Noller, M.S. in E.E., Dec. 1939.

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The design and construction of a surge generator for the electrical engineering laboratories, David C. Pinkerton, M.S. in E.E., June 1939.

Case School of Applied Science

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University of Colorado

Mathematical models applied to electrical engineering, Clinton Louis Conner, M.S. in E.E., June 1939.

Theory, design, and construction of electrical wave filters, Tudor Raymond Finch, M.S. in E.E., June 1939.

Arc welding generators, Edward John Wagner, M.S. in E.E., June 1939.

Columbia University

Experimental analysis of asymmetrical alternator short-circuits, Morton Horace Adolphe, M.S. (E.E.), 1938–39.

Power relations on regulated line with distributed parameters, William Killian Bernius, M.S. (E.E.), 1938–39.

Frequency and impedance measurements at one to two meters (150–300 megacycles), Nathaniel Braverman, M.S. (E.E.), 1938–39.

Transient reactances of generators, William Conrad Busch, M.S. (E.E.), 1938–39.

Calculation and test of loaded alternator experiencing line-line short circuit, Anton Henry Doblmaier, M.S. (E.E.), 1938–39.

The plans of the Federal Power Commission, Morton Peter Duffy, M.S. (E.E.), 1938–39.

The future possibilities of power production, Larner Montgomery Gambrill, M.S. (E.E.), 1938–39.

Study of transient exciter response, James England Hulsizer, M.S. (E.E.), 1938–39.

Oscillation and transient phase angle of synchronous motor on sudden change of loading, Howard Marshall Smith, M.S. (E.E.), 1938–39.

Characteristics of monocyclic network, Joseph Duvall Thompson, M.S. (E.E.), 1938–39.

Power gain and plate efficiency of various types of VT doubler circuits, Edward Graham Caldicott (E.E.).

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An investigation for diffusion in directional antenna fields, Millett Granger Morgan, M.S. in Eng., Sept. 1938.

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A preliminary design of a municipal steam-electric plant for the City of Columbia, S. C., Theodore Marion Hoefer, M. S. in Eng., June 1939.

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A short impulse method for determining coefficients of sound absorption, S. H. Pierce, M.S. (E.E.), June 1939.

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A feed-back circuit for reducing the effective internal impedances of amplifier tubes, Robert James Ehret, M.S., June 1939.

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Electronic voltage regulators, George De Socio, M.Eng., June 1939.

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Calculations of flux densities surrounding reactors, Robert Dean West, M.S. in E.E., July 1939.

The Harvey County rural electric development survey, Dennis Emerson Wiant, M.S. in Ag.Eng., July 1939.

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Massachusetts Institute of Technology

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Vacuum tube equilizers, John Henry Craig, M.S. in E.E., June 1939.

Control and regulation of high voltage by photoelectric cells, Thomas Garber, M.S. in E.E., June 1939.

Direct-current braking of an induction motor, Sylvan Gerald Glick, M.S. in E.E., June 1939.

Photographic study of discharge phenomena, Roy Caldwell Hopgood, Jr., M.S. in E.E., June 1939.

Bi-conical electromagnetic horn radiator, Johannes Jan Jansen, M.S. in E.E., June 1939.

Method for expediting watthour meter adjustment, Forrest Hamilton Judkins, M.S. in E.E., June 1939.

Design of a radio noise meter, James Davis McLean, M.S. in E.E., June 1939.

Flexure and shear vibrations in quartz plates, Francis Xavier Maida, M.S. in E.E., June 1939.

Attenuation of sound in tubes, Jonathan Russell Roehrig, M.S. in E.E., June 1939.

Pyroelectric property of Rochelle Salt in temperature measurement, Harry Ogden Saunders, Jr., M.S. in E.E., June 1939.

Development of an angular accelerometer, John Oscar Silvey, M.S. in E.E., June 1939.

Effect of rapid-reclosing circuit breakers on transient stability in power systems, Firm Lionel Weaver, M.S. in E.E., June 1939.

Investigations of the capacitron and its applications, Luciano Bendi, M.S. in E.E., June 1939.

Comparison of calculations and tests for transient stability, Boonrod Binson, M.S. in E.E., June 1939.

Theory of capacity igniters for mercury-pool tubes, Frederick Quincy Gemmill, M.S. in E.E., June 1939.

Harmonic torques in single-phase induction motors, Charles Harry Hoffman, M.S. in E.E., June 1939.

Method of comparing resistances at high frequencies, Pierre Marcel Honnell, M.S. in E.E., June 1939.

Measurement and analysis of errors in the cinema integraph, John Hayes Howard, M.S. in E.E., June 1939.

Calculation of synchronous torque in squirrel-cage induction motors, Takeo Ito, M.S. in E.E., June 1939.

Power system economy as influenced by power factor, Minard Albert Leavitt, M.S. in E.E., June 1939.

Subharmonics in a series ferro-resonant circuit, Clare Arthur McRoberts, M.S. in E.E., June 1939.

Sealed-off velocity-modulation vacuum tubes, Abbott Sherwood Maeder, M.S. in E.E., June 1939.

Study of the behavior of directional relays as applied to power network protection, Troy David Graybeal, M.S. in E.E., Dec. 1939.

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High voltage photocells and their application for high voltage control, Jack Rosenberg, M.S. in E.E., Dec. 1939.

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Acceleration and focusing of electrons in multistage tubes, Louis Dijour Smullin, M.S. in E.E., Dec. 1939.

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Realization of band-pass amplifier by utilizing negative feed-back principle, Bhagwan Das Toshniwal, M.S. in E.E., Dec. 1939.

Numerical solution of electrical circuit transients with the cinema integraph, Walter Thomas White, M.S. in E.E., Dec. 1939.

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Multiple electromagnetic horns, Carl Isaac Shulman, M.S. in E.E., June 1939.

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A study of direct-current corona on parallel wires in air, Hendrik Jacob Oorthuys and William James Jennings Walsh, M.S. in E.E., 1939.

Interconnection of electric power systems in the northwest, Bernard Iliff Valentine, M.S. in E.E., 1939.

Pennsylvania State College

Potential measurements in accelerated corrosion test, John Harold Snyder, M.S. (E.E.), 1939.

University of Pennsylvania (Moore School of Electrical Engineering)

The determination of the best distribution system for a certain territory, E. R. Streed, M.S. in E.E., June 1939.

An experimental study of violin tone vibrato, Octavio Salati, M.S. in E.E. June 1939.

Design of terminals to obtain uniform potential gradient at high voltage along a resistor connected between them, W. M. Shallcross, M.S. in E.E., June 1939.

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University of Pittsburgh

Motor operation of railway switches, Clarence W. Dalzell, E.E., June 1939.

The axial repulsion of a shortcircuited secondary turn, Paul H. Lindon, M.S., August 1938.

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A modified design of the 'Legg type galvanometer' to record heart voltage, Hervert T. Rights, M.S., June 1939.

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An investigation of the amplidyne generator, J. R. Whipple (E.E.).

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A study of resistance of neutralization in coupled circuits, Gordon Whitney Seaward, M.S. in Eng., June 1939.

Preliminary design of the Nanking-Tsishuyen power tie line, Shih-Jen Wang, M.S. in Eng., August 1938.

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A wide range laboratory oscillator of simple design, Leonard Marion Jeffers, Jr., Engr. (E.E.), June 1939.

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A design procedure for resistance coupled amplifiers, Charles Winslow Palmer, Engr. (E.E.), June 1939.

Frequency response characteristic of amplifiers employing negative feedback, Wen Yuan Pan, Engr. (E.E.), June 1939.

A stable vacuum-tube voltmeter, Donald Roy Peterson, Engr. (E.E.), June 1939.

The construction of low grid-loss receiving tubes, Edwin Norris Procter, Engr. (E.E.), June 1939.

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A study of high efficiency grid modulation, Horace Myrl Stearns, Engr. (E.E.), June 1939.

Inonosphere measuring technique, William Tileston Sumerlin, Engr. (E.E.), June 1939.

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The design and application of an electronic phase angle meter, Will Otis Leffell, M.S., August 1939.

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A vacuum tube voltmeter for effective values of rectified voltages, Jesse Byron Rawls, Jr., M.S. in E.E., June 1939.

Opposition heat runs on transformers utilizing frequencies other than that of excitation, Attie Lester Betts, M.S. in E.E., Aug. 1939.

University of Texas

High-frequency band-pass filters, Robert Francis Romero, M.S. in E.E., June 1939.

Excitation of induction generators by means of static condensers, Jack Edward Schrameck, M.S. in E.E., June 1939.

Inverse feedback in a direct-current amplifier, John Griffith Traxler, M.S. in E.E., June 1939.

An alternating-current network analyzer, Thayer Elmo Acord, M.S. in E.E., Aug. 1939.

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The effect of lubricating oil on the puncture strength of paper insulation, Herman Morris Koslow, M.S. in E.E., 1939.

The operating characteristics of a synchronous motor and their relation to stability, Ralph Louis Simenson, M.S. in E.E., 1939.

A study of the lines of flow and the equipotential lines in a plate conductor, Willard Harris White, M.S. in E.E., 1939.

West Virginia University

Purchase of electric power and energy for mining preparations in southern West Virginia, George C. Barnes, E.E., June 1939.

Experience in transmission line and substation construction operations and maintenance on 20 and 38 KV systems, Plinio E. Zerbi, E.E., June 1939.

University of Wisconsin

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Characteristics of compressed air cable, William Parke Frawley and Raymond Kenneth Houston, M.S. in E.E., June 1939.

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Magnetic recorder, George William McKenna, M.S. in E.E., June 1939.

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Radiating characteristics of loop aerials, Everard Mott Williams, Ph.D., June 1939.

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A thyratron circuit for theatre lighting, Carl Riehle Wischmeyer, M.Eng. (E.E.), June 1939.

Mechanical Engineering

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Hardness testing of light gauge sheet steel, Marshall Oliver Crumbaker, M.M.E., May 1939.

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Heat balance of a unit heater, Claes Albert G. Blomquist, Jr., M.S. in M.E., June 1939.

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An investigation of vibration phenomena in torsional systems having non-linear spring characteristics, Carl Arthur Peterson, M.S. in M.E., May 1939.

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Friction of angular-contact ball bearings under thrust loads, Joseph Levy, M.S. in M.E., September 1939.

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On the evaporative cooling of water drops, with a consideration of drop dynamics, Herbert Bradley Nottage, M.S. in M.E., September 1939.

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The development of an undergraduate problem in factory layout and planning, Robert Eugene Fromson, M.S. in M.E., June 1939.

A study of the methods for calibrating low-velocity air meters, Albert Henry Marty, M.S. in M.E., June 1939.

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The design of a restaurant unit, Paul Harold Taub, M.S. (I.E.), 1938–39.

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A comparison of certain physical properties of double V-Type arc welded joints, Howard Preston Davis, M.S. in Shop Practice, July 1939.
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An investigation of the performance of cross-flow heat exchangers used in air conditioning, Eneas Willon Kane, M.S. in M.E., July 1939.
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Development of a new type of self cleaning oil bath air cleaner for use on engines and compressors, Howard M. Fitch, M.S. in M.E., 1938–39.
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Lehigh University

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The design of a modern cane sugar factory and refinery, Wilmer M. Grayson, M.E. (La. State Univ., Abstracts of Theses, Vol. 31 N.S., No. 1, p. 25, 1939.)

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Some economic aspects of airline operating costs, Chauncey Frederick Bell, Jr., and W. W. Bender, Jr., M.S. in Econ. and Eng., June 1939.

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Heat transfer coefficients for an SO_2 evaporator, William Mary Scenna, M.S. in M.E., June 1939.

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Effect of forging on centrifugally cast gun steel, Daniel John Murphy, M.S., June 1939.

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A study of thermocouple installations, Herbert Frederick Wiegandt, M.S. in Eng., June 1939.

The supercharging of a 50-horsepower airplane engine, Dale Emmet Wilkins, M.S. in Eng., June 1939.

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Wind tunnel turbulence studies using a crystal pickup, Rossa William Cole, M.Aero.Eng., June 1939.

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An investigation of dust explosions, Michael Pavulak, M.M.E., June 1939.

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THE RELATIONSHIP OF COST ACCOUNTING AND ENGINEERING ECONOMY *

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Practically the whole literature of cost accounting should be rewritten. Nearly every cost system needs major revision. Cost accounting, especially the text-book variety, has evolved with little reference to objectives. As a result, it is an expensive way to be misled into making mistakes.

A new cost accounting should begin with a careful analysis of purposes; and the objectives delineated should never be forgotten. This would make engineering economy a starting point for cost theory and a goal of cost practice. The relationship is like that of nervous system and brain. Cost accounting gathers data, engineering economy interprets the data gathered. The two should never have been considered or taught as separate subjects.

This pragmatic philosophy forces the present paper to begin with a discussion of objectives, continue with an analysis of technique, and conclude with implications as to teaching.

Objectives

Cost accounting and engineering economy are methods of accumulating and interpreting certain types of data for the use of managers. The purposes of managers should fix the objectives and character of cost accounting and of engineering economy. A major objective of private managers is profit-making, of public managers the rendering of the best service at least cost. This is the only managerial motive of importance to cost accounting or to engineering economy.

All managers first plan and then execute; in a social environment which exerts certain controls and which they attempt to influence. Managers need data as a basis for plans, as an aid in fixing responsibility for the execution of plans, and in the contacts with the social environment. Cost accounting and engineering economy seek to secure and interpret part of these data.

* Presented at the 48th Annual Meeting, S. P. E. E. (Industrial Engineering and Engineering Economy), University of California, June 24–28, 1940.

Accounting is limited to an enterprise-centered pecuniary record of the past. General accounting is a pecuniary history of the buying and selling operations of an enterprise, of its trading with other economic entities. Cost accounting is a pecuniary history of physical activities occurring within the enterprise. Budgets and standard costs are pecuniary estimates of corresponding future activities. Time and material standards are examples of non-pecuniary estimates, while records of actual times and material usage are examples of nonpecuniary historical data. Data concerning markets and general economic conditions are used by managers but are not enterprise-centered.

Management uses all of these types of data as a background for planning, as a means of enforcing plans, and as an aid in making social contacts. The need of management for data to aid in performing each of these major functions is the basic reason for incurring the expense of cost collection, yet cost accounting is poorly adapted to this work. It needs complete reformulation, beginning with reorientation of its theory, sweeping through all of its method, and ending with a new and appropriate interpretation of its findings.

Much of managerial planning involves selection among alternative courses of action. Engineering economy seeks to solve these problems of managerial choice, to answer the question, "Which is most favorable? Which pays best?" Thus engineering economy provides one of three objectives for a new rational cost accounting. However, the pragmatic spirit of engineering economy as exemplified in Grant's "Principles of Engineering Economy" and Clark's "Economics of Overhead Costs" should be extended to the interpretation of cost data in terms of individual responsibilities for executing plans and in terms of the interplay of the enterprise and its social environment. This spirit has little use for the fictitious allocations between departments and products so characteristic of traditional cost accounting. It concentrates on causes and effects; on differences, variations and correlations. It ties its pecuniary arithmetic to actual changes or to alternatives in physical activities. Its typical statement follows this pattern: "If these activities are undertaken, these changes in enterprise (or social) welfare will result. If these activities had not been performed, these differences in enterprise (or social) welfare would have occurred."

Managerial planning, executing and representing, as orientation of a new cost accounting, require further elaboration in the course of which consideration will be given some of the many ways in which traditional cost accounting misleads or fails to inform management.

Planning

Planning is the field of engineering economy as well as an objective of a new cost accounting. Planning may be further divided into (1) formulation of policy, (2) design of product, (3) development of organization pattern, (4) choice of method, (5) selection of resources, and (6) pricing of product. The tangible aspects of each type of planning fit into the patterns of engineering economy studies.

(1) Policies are relatively permanent general plans. A degree of permanency makes for consistency in relationships and avoids the costs of repeated investigations to solve series of similar problems. A general plan goes far toward coördinating activities contemplated by the plan. A few such plans can be worked into a coördinated system more effectively than can the myriad of detailed activities governed by such a system. Thus policies produce consistency, economy and coördination.

Policies can be classified in many ways. One of the most fruitful is to arrange policies in an hierarchy paralleling the organization pattern. The most general of policies are formulated by the board of directors. Each lower rank of executives formulate successively more detailed plans within an ever narrowing frame of policies imposed from above. Policies decided by top management usually involves such important intangibles as to exclude the methods of engineering economy. Examples of such broad policies are choice of industry, of competitive level, of degree of aggressiveness. Below these, but still high in the hierarchy of policies, budgets become useful tools. Among such problems of policy are location of plants and sales branches, completeness of line, selection of channels of distribution, and so on. As plans narrow and become more sharply defined, budgets become more accurate and specific. Finally a zone is reached which yields to the methods of engineering economy.

(2) There are policies which govern product design in a general way. An enterprise may elect to enter the quality or the price market. Typically this is a decision for the board of directors: full of imponderables, requiring a high order of judgment, of great importance, but seldom reducible to a simple problem in cost comparison. The policy adopted will set limits to design as to tolerances, finish and grade of materials. Yet policies may be abandoned or altered, and there are gradations within the limits set by policy. Thus it becomes important to know the cost differences associated with any contemplated change in design. Such cost data help the board of directors formulate policies of product quality and largely determine finer decisions within the limits set by policy.

Often many designs will acceptably meet the requirements of market and policy. A company with several plants was faced with a choice between sheet metal and plastic packages. The initial investment for dies for plastic packages was much greater than for sheet metal, but subsequent material and labor costs per unit were lower. Costs for each package were computed for various annual volumes and the cross-over point found. Plants with a smaller annual volume used the sheet metal package. Those with annual volumes in excess of the cross-over volume used the plastic. Here a typical engineering economy study drew much of its data from cost records which may have been adequate.

(3) The organization pattern is partly determined by general policies, partly by a knowledge of human nature tempered with judgment, partly by available personnel and partly by the relative costs of different possible organization patterns. Departments and jobs are specialized in order to employ less versatile and consequently less costly personnel and to make fullest use of the talents hired. However, these specialized activities must be coördinated. When specialization is greater, coördination becomes more necessary, difficult and expensive. Here is another of the typical patterns of engineering economy: a course of action which will reduce one set of costs is accompanied by another set which increase. The proper balance is achieved when the total cost is minimized. Part of the necessary data are drawn from the accounting records, the rest are even less reliable.

(4) Production methods have long been a happy hunting ground of cost accounting and of engineering economy. Years ago, an A. S. M. E. committee on materials handling developed a formula for comparing alternative methods. It must delight traditional cost accountants. It is full of averages, allocations and sunk costs, and utterly lacking in the nice discriminations of engineering economy or of the new cost accounting here urged. For example, it does not discriminate between an enterprise (using shovel and wheelbarrow) contemplating installation of a conveyor, and another using a conveyor and considering scrapping it in favor of shovel and wheelbarrow.

(5) Closely related to choice of method is selection of equipment. This is a special case of selection of resources and is easily generalized to include choice of location or materials. The familiar problem of Machine A *vs.* Machine B can be extended to include San Francisco *vs.* Oakland or cast iron *vs.* stainless steel. Extension to the selection of human resources is not easy and should not be attempted until psychological testing becomes more reliable.

(6) Pricing is a last and very important planning problem of management. Usually the problem is one of getting more business

at lower prices or less at higher. In contract lines, each quotation raises the pricing problem and the tendency toward price cutting is often very evident. Perhaps the most frequently cited advantage of cost systems is the help they are reputed to give management in setting prices. Yet nowhere is the failure of traditional costing and need for a new cost accounting more conspicuous. Traditional cost accounting works badly because it has lost touch with its objective. The objective without much technique may work better.

Many a small company has been magnificently directed by a manager without training in cost accounting but with an almost perfect cost system in his head. As founder, chief designer, general manager and star salesman, such a man accumulates all the data gathered by the best of cost systems. His common sense selects, classifies, regroups, analyzes and interprets this information to best effect. The traditional cost system makes such commonsense analysis impossible by merging and suppressing important data.

Imagine a commonsense manager facing a contract job. It offers opportunity to rework spoiled materials otherwise probably beyond salvage, so he whittles the material cost. The job threatens overtime on key machines, so he adds appropriate premiums in figuring labor cost. Other machines which would be used are operating below capacity. If he can absorb part of the idle overhead he will lose less than if they continue idle, so he cuts his figure on machine charges. By consolidating purchases for this and other jobs he can secure additional quantity discounts, so he makes an allowance for cost reduction on the other jobs. And so he pieces costs together logically and with direct reference to his money-making objective.

The business prospers and grows under this realistic direction. Finally the mind of its chief is stretched to the limit in absorbing and using data. He leaves a big and prosperous company to his son. The son has not grown up with the company, accumulating data for half a century. He has not had his finger in every pie. His is a desperate need for information. The best of cost systems is hurriedly installed. It reports average machine hour costs. It reports the historical costs of materials. It loses overtime premiums by averaging them over all jobs. Pricing gets tied up in a rigid strait-jacket. The business begins to get many jobs which jam critical production centers and loses other jobs which could go on machines standing idle. The cost system produces chaos and losses.

Perhaps I am complacent, but to my mind the theory of managerial choice is crystal clear. I believe Clark and Grant have enabled us to transfer the tangible aspects of engineering economy (of managerial choosing) to the finished business file. Careful de-

scription of each alternative enables separation of relevent from irrelevent data. Only differences between alternatives are important. Engineering economy is applied pragmatism; where there are no differences, there can be no problems of choice and engineering economy cannot take hold. All of the past is disregarded as common to all alternatives and consequently irrelevent. Next, the estimated physical differences between various possible planned futures are priced. This may involve analysis of cost records, making of technical experiments or survey of markets. These estimated pecuniary differences are adjusted for risk and accumulation of interest. The final step is comparison and choice, giving full attention to imponderables.

In all this planning, traditional cost accounting fails abjectly. Most cost systems are too slow; *e.g.*, a fulltime clerk was compiling costs of tool making nine months after the tool was completed. Even when the system reports promptly, it is likely to report ancient history. The all too prevalent first-in, first-out inventory rule may result in stating costs at prices quoted in markets months past.

Cost systems are full of fictions. The most glaring is the persistence well nigh to immortality of sunk costs. An irretrievable investment is placed on the books as an asset and charged as depreciation into all costs, for whatever purpose they may be used, until amortization is complete. Meantime true costs (which are largely market prices) change, designs become obsolete, locations shift, and still past error guides present action toward wrong future patterns.

Joint costs are a further source of accounting fictions. Productive resources are bought in bundles at bundle prices. Once acquired, they are split into relatively small but often physically similar pieces. The cost clerk parallels this physical performance by dividing the pecuniary values assigned. Later as these physical pieces are used by departments or enter into finished product, the cost accountant continues his pecuniary parallel, subtracting and adding to find departmental and product costs. The fallacy of this basic assumption is shown by the following: Buildings are usually rented for a period of years. Cost accountants calculate a departmental charge per square-foot-hour by straight division. All square feet are not equally valuable, nor are all hours. The cost accountant avoids the worst difficulties by dividing total rent paid by "productive" square feet instead of total square feet, and by operating hours. This charges aisle space and overnight shutdown hours at a zero rate. He ignores all in-betweens. His world is black or white; there are no grays to the cost accountant. Slack

periods are charged the same rate as peak, which makes fill-in repair work discouragingly expensive. A department may be cramped for space while areas lie vacant because the department head does not want additional area charges placed against him.

Execution

Managerial execution involves both motivating and inspecting. Cost accounting has a role to play in each. Both are foreign to engineering economy, although the pragmatic spirit of the economy study contains valuable suggestions for revitalizing cost accounting in this application.

Cost accounting may be used as a motivating force. If a foreman aids in setting cost standards, he gains an appreciation of the why of planning, and of the organic interlocking of all the activities of the enterprise. He sees why it is important that he make his plans work. Moreover, his constant striving to do better than standards specify leads to making better plans for subsequent periods.

Cost accounting has long been used as an inspection device. Department heads are called on the carpet to explain why current costs exceed the standard, and to tell what they have done to remedy the situation.

Both as motivating device and inspecting agency, traditional cost accounting is deficient. Its averaging and irrational allocating pervert it. Some allocations of uncontrollable charges do little damage as they enter both standard and performance equally, thereby merely diluting real shifts of significance. Others obscure real factors or actually mislead effort. For example, a foreman schemed to reduce floor area requirements, thereby reducing space charges and earning a fat bonus. Since his company already had excess space, it refused to make a small investment for tiering equipment, destroyed the foreman's morale, and ruined its cost reduction bonus plan.

Only such costs should be charged against departments as the management wants foremen to worry about. In a very old and very crowded plant, floor space was at a premium. Operations were cramped and expansion impossible without incurring a very expensive move. Here it did not harm to multiply the accountant's square-foot-hour charge by five or ten. Charging the higher rate gave foremen a substantial awareness of the need for conserving floor space.

Representing

Traditional cost accounting is best adapted to the needs of the manager acting as representative of his company. Governments,

customers or creditors may demand information. Since they have been trained in the old cost accounting, they demand data produced by orthodox methods. The manager can satisfy them only by reporting the resulting insane data.

Consider the cost plus contract. What is cost? Evidently this is a matter to be agreed upon by the contracting parties. The contract should outline the system of costing to be used. Some munitions contracts do stipulate the amortization rates to be used in figuring machine overheads. A Chicago manufacturer supplies goods to a New York selling company at 110 per cent of direct material plus 200 per cent of direct labor. This introduces an agreed upon arbitrary charge for overhead, but eliminates the maze of judgment, opinion and error of the traditional cost system. There is no connection with real or book overhead. Where a contract does not stipulate a method for calculating a so-called cost, reliance must be placed on custom. If cost is always figured in a certain manner, no discrimination can be claimed.

The arbitrary cost rule set by contract or custom, based on prevailing cost theology, may damage both parties. Such a cost may be high enough to limit buying to the hurt of both buyer and seller; whereas a price, figured as the owner-manager-salesman figured, would result in a mutually profitable sale. So much for objectives and the failures of the old technique to do the mob managers need done. A new technique designed to supply data needed by management is outlined below.

Technique of a New Cost Accounting

"One look at the original data is worth any number of averages." The illustrations above amply confirm this dictum. The problem of the new cost accounting is to preserve original data in the most accessible form, to allow for reshuffling into new groupings as occasion arises. Original data should not be irretrievably merged in a relatively few large accounting classifications. Any one account should contain only such items as follow exactly a single law of variation. Herein was the strength of the owner-manager-salesman. His data were accessible, detailed, unmixed, and reclassifiable.

This rule of flexibility holds for both planning and executing. Correct power cost estimates are vital to intelligent choice between electric and gas ovens. A typical rate for industrial power consists of four separate charges: (1) a charge per kilowatt-hour, (2) a demand charge based on the largest hour's consumption during the preceding twelve months, (3) a charge for maximum service

during the utility's daily peak, and (4) a premium or penalty for the power factor. These four components follow separate laws of variation and should not be merged in a single power account. Nor should they be lost in a maze of allocations to departments or products.

There has been a commendable tendency in recent years toward supplying management with detailed physical data; actual performance paired against standards. For example, one system of growing acceptance calls for a report every morning on the preceding day's direct labor. A summary report has columns for standard and actual hours, standard and actual costs, and per cent variation in hours and costs. Each shop department has a line. Each line is supported by a departmental sheet showing similar data for each workman and job. Workmen fill in time tickets, one for each job. Each such time ticket becomes a line on the departmental report with subtotals for each workman. The superintendent glances at the summary report and turns to the reports of departments which have deviated most from standard. There he traces difficulties to specific jobs and men. Soon he calls in the foremen and asks for reasons, and as to what remedial steps have been taken. This follow-up is swift and sure, coming as it does the very morning after the trouble has developed. Every foreman expects it and stays on his toes. Each foreman receives a copy of the summary sheet and of his own department's record.

These daily records are summarized weekly and monthly. The monthly summaries, with a line for each workman and a page for each department, are permanently filed in the personnel department. There they serve as a basis for adjusting wages according to individual performances and for promotion, transfer and lay-off. All this is explained to every workman. He becomes extremely aware of this detailed record of performance. It becomes a matter of small moment as to whether straight time (measured day rate), piece rates or bonus wage plans are used. The man's record is known to management and is reflected in both pecuniary and non-pecuniary rewards—becoming both a motivating and an inspecting device.

Overhead is controlled in terms of items subject to increase or decrease according to the efficiency of the department head. These items are budgeted both in physical and in pecuniary terms. Most are placed on a weekly basis, the balance on a monthly. Weekly and monthly reports are prepared promptly, showing each item for each department with columns for budget, actual and per cent variation. These are summarized quarterly and become a perma-

nent personnel record governing the future of the department heads as to promotion, salary, bonus and dismissal.

As the plan actually works, the pecuniary data are used only as a rough measure of the importance of each item. All discussion, planning and action take place in terms of the physical aspects of performance: labor hours, pounds of steam, kilowatt-hours, etc. Some day the philosophy here outlined may be carried a step further. The values ascribed to various items may be completely divorced from present accounting practice and become solely an index of importance of the item as judged by higher management. Departmental "costs" will become a weighted index of efficiency. This system is an almost perfect extension of direct personal contact with operations. It stays close to the actual physical terms in which plans are executed. It requires prompt and continuing follow-up; merely acting as a guide to point direct contact to those spots which need it most.

Tabulating equipment seems the only practical solution wherever the data are too voluminous to be carried in one man's memory. With tabulating equipment, each event can be recorded in complete detail on a single card. Items following a single law of variation can be selected by tabulator and summary cards automatically punched. Both summary cards, which correspond to a very detailed cost ledger, and detail cards, which correspond to a journal, should be kept conveniently filed. The summary cards, or the more detailed ones, can be further tabulated, grouped and summarized in various ways as the need arises. The resulting summary cards can be filed if the problem is likely to recur or if the classification happens to be useful for other purposes. In many instances, after regrouping and finding new totals, the problem will be settled and the special summary cards thrown away.

This tremendous detail is neither impossible nor overly expensive. A plant producing heavy road machinery has reduced all material and operation standards to punched cards. A shop order for steam shovels begins with the automatic duplication of nearly 10,000 tabulator cards. These cards are both printed and punched automatically from a file of master cards kept by the planning department. The duplicate cards are released to the shop as needed. They include every material, tool and fixture requisition, every operation instruction; everything is there. The cards show the type of machine to be used, feeds and speeds, specifications and amounts of materials, standard times and costs. The cards constitute a complete set of instructions from the planning department to the shop.

The shop carries out the orders, writes in actual times and

spoilages and returns the cards to the tabulator. The shop data are punched into the cards and tabulator reports run off. The returning cards act as reports to the planning department as to materials issued and machine and labor time. All the reports needed by management; machine loadings, departmental efficiencies, job progress, payrolls, and so on, are obtained by successive mechanical passes through tabulating equipment. At this time any desirable summary cards are punched preparatory to monthly reports. Even the payroll checks are mechanically printed from summary cards automatically prepared.

This method has given closer control, more detailed and accurate information, much more timely than the company has ever had. Yet it has reduced the costs of planning and cost keeping by about one-half. I will agree that an immense preparation is necessary in setting all the standards necessary to the punching of thousands of master cards.

Teaching

Technical engineering students are concerned solely with problems of managerial choice; as to method, design and equipment. Emphasis for such students should be placed on engineering economy; on the use and supplementing of cost data from other sources to solve these problems of choice. With cost accounting in its present deplorable state, it is vitally necessary to sketch and criticize present cost techniques. Only so can the data contained in cost records be made safely available to the engineer. This subject matter will be as interesting to industrial engineering students, students of business administration and accounting students as it is to technical engineering students. Consequently a course might be set up to do this job for all students.

Industrial engineering students will be equally interested in broader problems of managerial choice, in problems of control, and in cost techniques (because of the intimate relation to planning routines). The first course, recommended above, could be followed by a second course on costing as a control technique. Technical engineering students could elect or ignore this second course; but industrial engineers, students of administration and accounting students should be required to take the course.

A third course in pricing and representing should be required of students of business and accounting and be optional for engineering students. In each of these first three courses in the accounting sequence, the emphasis should be placed first on the nature of the managerial problem, second on the types of data needed to solve such problems, and thirdly on the general outlines of a technique to secure these data.

Courses in accounting procedures and routines should be reserved for later treatment. They would be available for accounting students and avoidable by all others. This substantially reverses present procedure. All students exposed to accounting now begin with a course in which journals and ledgers play a prominent part, and the student wastes hours on bookkeeping. Later they may be subjected to courses in business management. Engineering economy is usually taught as an unrelated subject, if at all. By treating the objectives (managerial problems) first, the courses in technique could follow a logical development, examining each report as to its usefulness and each record as to its adequacy and economy in producing reports.

Thus engineering economy, as one of three major objectives and therefore a dictator of the content of accounting reports, becomes an integral part of the basic courses in accounting and costing.

CONSTITUTION OF DIVISION OF INDUSTRIAL ENGINEERING OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION *

ARTICLE I—*Name*

The name shall be the Division of Industrial Engineering of the Society for the Promotion of Engineering Education.

ARTICLE II—*Aims and Objectives*

The general aims and objectives shall parallel those of the Parent Society. Specifically they shall be to stimulate interest and promote progress in the field of the teaching of Industrial Engineering. The term Industrial Engineering is defined to include as a "generic" name, curricula going under the names of administrative engineering, commercial engineering, management engineering, and business and engineering administration.

The several aspects of Industrial Engineering include:

Methods: Tool Engineering, Motion and Time Study, Operation Analysis, Factory Planning.
Cost Control: Cost Accounting, Budgetary Control, Standard Costs.
Personnel: Industrial Relations, Industrial Psychology.
Organization: Industrial Administration, Management and Coördination.
Operating Control: Inventory Control, Production Control, Storekeeping, Inspection.

ARTICLE III—*Membership*

Membership is open to all members of the National Society who are interested in the problems and teaching of Industrial Engineering (generic meaning).

ARTICLE IV—*Officers*

The officers of the Division shall be a Chairman, a Vice Chairman, a Secretary-Treasurer, and an Editor.

ARTICLE V—*Executive Committee*

There shall be an executive committee consisting of four elected members and the immediate past chairman. The Committee shall be self-organizing, electing its own officers. The Committee officers shall be the officers of the Division. The immediate past-chairman shall not be an officer.

Executive Committee members shall serve for a two-year period, two members, normally, being elected each year.

* To be presented for adoption at a dinner meeting to be held by the Division on the evening of Wednesday, June 25.

ARTICLE VI—*Nominations and Elections*

The chairman shall appoint a nominating committee of three members. This committee shall present two names for each place on the executive committee which is to be filled. Nominations shall be made by this committee sufficiently early in the year to allow for printing in the Journal previous to the annual meeting. Nominations may also be made from the floor at the time of the election.

Election for members of the executive committee shall be held at a business meeting in conjunction with the annual meeting of the society. Balloting shall be by written ballot. Those elected shall take office at the close of the annual meeting at which they are elected.

ARTICLE VII—*Advisory Group*

There shall be an advisory group to the Executive Committee consisting of one member from each of seven regions. These regions shall be the regional set-up of the Engineer's Council for Professional Development as follows:

Region No. 1. Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut.
Region No. 2. New York, New Jersey, Pennsylvania, Delaware, Maryland.
Region No. 3. Ohio, Indiana, Illinois, Iowa, Minnesota, Wisconsin, Michigan.
Region No. 4. Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Kentucky, West Virginia.
Region No. 5. Missouri, Arkansas, Louisiana, Texas, Oklahoma, Kansas.
Region No. 6. Colorado, New Mexico, Arizona, California, Nevada, Utah.
Region No. 7. Oregon, Washington, Idaho, Montana, Wyoming, North Dakota, South Dakota, Nebraska.

This advisory group shall be appointed by the executive committee for a two year term. Appointment shall be made so that not more than four members will be appointed each year.

ARTICLE VIII—*Special Committees*

Special committees shall be appointed from time to time to work on special problems which shall be carefully defined. Any special committees shall be appointed by the chairman upon the advice of the executive committee, the advisory group or the vote of the division at the annual meeting.

ARTICLE IX—*Amendments*

This constitution may be amended by a two-thirds vote of the members present at any annual meeting of the division, provided notice of the contemplated amendments has been sent by mail to each member of the division at least thirty days before the annual meeting or published in the Journal of the Society.

ARTICLE X—*Dues*

Any necessary dues of the division shall be determined each year by the executive committee, and voted on by the members of the division at the annual meeting. The dues shall be only for incidental items which are not supplied by the National Council.

ARTICLE XI—*Meetings*

The Executive Committee shall arrange for a program to be held in connection with the Annual Meeting of the National Society. These shall be open meetings for all persons interested in industrial engineering (generic meaning). The Editor shall collect copies of all papers for use of the national secretary.

Executive Committee:

C. W. BEESE — G. W. BARNWELL — L. P. ALFORD
H. G. THUESEN — A. S. KNOWLES — H. J. MCINTYRE
C. E. BULLINGER, *Chairman*

NEW MEMBERS

BANMILLER, PAETRUS F., Registrar, Villanova College, Villanova, Pa. J. S. Morehouse, H. S. Bueche.

COHN, BRYON E., Professor of Physics and Electrical Engineering, University of Denver, Denver, Colo. Chester Russell, F. L. Bishop.

DAVIS, STEPHEN S., Instructor in Mechanical Engineering, Howard University, Washington, D. C. A. E. Richmond, D. E. Howard.

HASKINS, GEORGE W., Major, Air Corps, U. S. A., Inspection Division, OCAC, Washington, D. C. Re-admission.

KNIGHT, ODON S., Assistant Professor of Chemical Engineering, Rose Polytechnic Institute, Terre Haute, Ind. Carl Wischmeyer, H. W. Moench.

LAITALA, EVERETT, Instructor in Mechanical Engineering, University of Minnesota, Minneapolis, Minn. C. A. Koepke, J. J. Ryan.

O'MEARA, THOMAS J., Instructor in Electrical Engineering, Manhattan College, New York City. J. F. Renitges, H. J. Lockwood.

QUAGLIANO, JAMES V., Instructor in Chemistry, Villanova College, Villanova, Pa. J. S. Morehouse, H. S. Bueche.

SCHUMAN, ETHEL K., Assistant Professor of Eng. Language, University of Denver, Denver, Colo. Chester Russell, F. L. Bishop.

T'ANG, CHEN-HAU, Assistant in Hydraulics, Cornell University, Ithaca, N. Y. J. E. Perry, S. C. Hollister.

WATTS, CALVIN T., Assistant Professor of Civil Engineering, Louisiana Polytechnic Institute, Ruston, La. R. T. Sessums, B. T. Bogard.

WEEDEN, HARMER A., Instructor in Civil Engineering, Bucknell University, Lewisburg, Pa. R. L. Anthony, D. M. Griffith.

UNIVERSITY OF CONNECTICUT, Storrs, Conn., J. H. Lampe, Dean.

193 new individual + 1 institutional member this year.

COLLEGE NOTES

University of Detroit.—The Faculty of the Engineering College is supervising defense program courses in Aeronautical Engineering, Engineering Drawing, Materials Inspection and Testing, Production Engineering, Production Supervision, and Chemistry of Explosives. The number of applications has far exceeded the authorized enrollment.

The Engineer's Council for Professional Development has approved the curriculum in Chemical Engineering, together with the facilities for teaching the courses involved.

Harry O. Warner, Head of the Department of Electrical Engineering, is directing the construction of a "Standards and Calibration Laboratory." The purpose of this laboratory is to calibrate electrical instruments accurately, to make precision measurements of electrical units used in circuits and equipment, to provide better facilities for teaching purposes and the preparation of theses, and to further research projects. Included in the equipment is a Weston Standard D.C. Voltmeter with accurate ranges of 3 to 300 volts, and a Gray Precision Kelvin Double Bridge for measuring resistances from 0.0000005 to 1.0 ohms.

Peter Altman, Head of the Aeronautical Department, resigned his position to become Director of the Research Division of the Aviation Manufacturing Corporation.

An Aviation Cadet Preparatory Course is being given under the auspices of the University of Detroit. This course is designed for the sole purpose of tutoring men for the educational examination for Flying Cadet to be given by the Army.

Eight new members added to the faculty during the past year include, John Uicker, Instructor in Mechanical Engineering who has received the degrees B.S. in Engineering, and M.E. from the University of New Hampshire. Before coming to the University of Detroit, Mr. Uicker was an Instructor at Penn State College. Anthony Satullo, Instructor in Electrical Engineering, who has received the degrees B.S. in E.E., and M.S. in E.E. from Case School of Applied Science. George H. Tweney, Instructor in Aeronautical Engineering, who has received the degree, B.Ae.E. from the University of Detroit. Mr. Tweney was formerly Junior Engineer, Pan American Airways, New York City, in charge of the Maintenance Engineering Office, where he also acted as Aerodynamicist and Flight Test Engineer. Henry George, Instructor

in Metallurgy, who has received the degrees B.S. in Ch.E. from Lehigh University and M.S. in Metallurgy from Carnegie Institute of Technology. William Judson, Instructor in Engineering Drawing, who has received the degree B.S.E. from the University of Michigan. Julius J. Toner, S.J., A.M., Instructor in English. James Farrell, S.J., A.B., and Edmund Montville, S.J., A.B., graduate assistants in English.

SECTIONS AND BRANCHES

At the meeting of the **Mid-Atlantic Section** of the S. P. E. E. held at the University of Pittsburgh in December, 1940, the following officers were elected for the coming year: Chairman, C. G. Thatcher, Swarthmore College; Vice-Chairman, G. F. Bateman, Cooper Union; Secretary, F. D. Carvin, Newark College of Engineering.

The next meeting of the Mid-Atlantic Section is scheduled for Saturday, May 3rd, at Villanova College.

FRANK D. CARVIN, *Secretary*

The Executive Committee of the Society has just approved the formation of the **Michigan State College Branch**. The officers are: C. L. Brattin, Chairman, and C. D. Beerup, Secretary.

BOOK REVIEWS

Thermodynamics. H. A. EVERETT. D. Van Nostrand Company, Inc. 2d Edition. 466 pages.

Revision of this text, intended for students of sophomore or junior standing, has been made for correction of data and minor errors in subject matter as well as methods of presentation in some instances. Naturally in a theoretical text obsolescence plays a minor part and one would not expect any very drastic changes as are caused by this factor in texts of practical application.

In the new edition the values of specific heats for gases have been revised to conform with the results obtained by spectroscopic methods.

The problems formerly compiled in a separate pamphlet have been included in a section at the end of the new edition. This accounts for the increase in the total number of pages from 430 to 466.

G. O. MANIFOLD

Professional Aptitude Tests in Medicine, Law and Engineering. I. L. KANDEL, Ph.D., professor of education, Teachers College, Columbia University, Bureau of Publications, Teachers College, Columbia University, New York, 1940. 78 pages.

This excellent booklet reviews the various attempts of the three professions to aid in selecting students who are better fitted to pursue a professional education. It is readable, contains valuable correlations of test data with student grades and compares the effectiveness of the three professions in student selection and prediction, which does not flatter the engineers.

Medicine. Under the supervision of a committee of the Association of American Medical Schools, a thorough study of the reliability and validity of selective tests was made over a period of years. The tests have been revised, checked, distributed and scored by the central office. Prospective students in some 700 premedical colleges take the tests annually.

The tests include "(1) general information; (2) vocabulary; (3) spelling; (4) logical reasoning; and (5) understanding of printed material."

Reports are submitted to the deans of medical schools to which students tested may apply for admission.

On the average "About 15 per cent of the (medical) students drop out on account of poor scholarship or for other reasons by the end of the first year and . . . from 20 to 25 per cent fail to graduate."

There is still considerable variation in the standards of admission because some schools admit those with lower test scores.

Comment, "Students with A.B. degrees do better work on the whole than students who have not graduated or who have graduated with other degrees; students admitted with only two years of premedical studies come second to students with the A.B. degree."

Law. "Schools of law, like schools of medicine have for many years been disturbed by the number of students who fail." So have schools of engineering.

Institutions, rather than an organization of law schools, began and carried on experiments to discover effective tests of ability on which to base selection. The author describes the investigations made and the reliable methods of selection devised.

There is not the centralization that characterizes the test procedure of the medical schools and a larger degree of individualism is present in the selective methods in use—"capacity tests," college grades, interviews, recommendations of deans and the information on the application.

Engineering. "The development and application of tests to discover ability to study engineering have had a longer history than either medical or legal aptitude tests. The history has, however, been chequered."

The author reviews the army tests of and following the first World War and which led "to the production of more types of aptitude tests than are available for any other profession." The support of the S. P. E. E. and E. C. P. D. are noted but the "work has been sporadic and conducted by individuals or in separate institutions." "This situation is all the more surprising because there has been made available more information about the qualities desired in an engineer than about those desired for practitioners of other professions."

Numerous references are made to the S. P. E. E. Investigation and the extensive and valuable data which it contained. Reports of various committees of S. P. E. E. are quoted. The Society and institutions are criticised for having data about students and "failing to provide for their proper use." The early experiments by E. L. Thorndike, the study by C. R. Mann, experimental studies at various institutions are mentioned, including Hammond and Stoddard on the Iowa Placement Examinations and many others. Such

batteries of tests as are in effective use at Carnegie Institute of Technology, Yale University and others are not mentioned.

The charge that engineering has a large amount of information but does not have an authority behind its classification and use seems justified.

R. L. SACKETT

The Literature of Junior College Terminal Education. LOIS E. ENGLEMAN AND WALTER CROSBY EELLS. Menasha, Wisconsin: George Banta Publishing Company, 1941, 322 pages. $2.50.

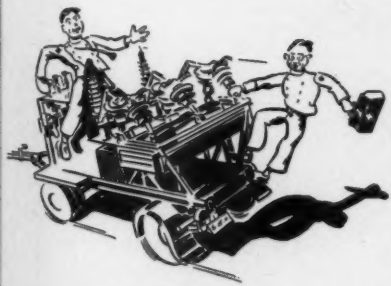
This volume, an annotated bibliography of all the significant materials on problems of terminal education at the junior college level up to January 1, 1941, is one of three monographs prepared by the Commission on Junior College Terminal Education of which Walter Crosby Eells is director. The other two monographs scheduled for publication this spring are: *Present Status of Junior College Terminal Education* and *Why Junior College Terminal Education.* These studies are the result of a year (1940) of exploratory study of terminal education on the part of the Commission, made possible by a special grant of the General Education Board. Additional funds have been appropriated by the Board to continue this study of terminal education during the next four years.

The present publication includes more than 1800 references dealing specifically with junior college terminal and semiprofessional education. References cover the period from 1900 to the present. Almost half the references are to publications of the last five years, reflecting the marked increase of interest in the field of junior college terminal education in recent years. References are carefully classified in more than 100 topical fields with many cross references by author, by source, by institution, and by curricula—thus facilitating ready reference and immediate use for a variety of purposes. More than 100 references have a particular bearing on engineering in the junior colleges. The annotations present the substance of the articles in sufficient detail to be of particular advantage to small institutions where original references may not be available in the library.

As indicated by Dr. Eells in the foreword of the book, "this volume will prove of distinct value to junior college administrators, faculty members, graduate students, and others interested in the various phases of terminal education, which is, perhaps, the most significant aspect of the rapidly spreading junior college movement."

C. A. ANDERSON

G-E Campus News



TO THE RESCUE

WHEN Mother Nature goes berserk, and whole towns are cut off from electric power, that's when repair crews go into sudden action to find the break and fix it.

In the past power companies have had transformers mounted on small trailers to be rushed to location to restore power. Now General Electric has announced a completely factory-built 1000-kva mobile substation, first of its type.

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INTRODUCING . . .

A NEW champion! The world's largest and most powerful industrial X-ray unit, packing a wallop equivalent to $90,000,000 worth of radium, is now at work in the General Electric plant at Schenectady.

Stronger by 600,000 volts than others in its class, the 1,000,000-volt monster clips down to two minutes the old record of an hour to take a picture through four inches of steel.

The machine is housed in a special building, with 14-inch concrete walls plus 12 inches of exterior brick to absorb stray radiations. Another safeguard for X-ray technicians is the X-ray safety "wrist watch"—a leather case, worn on the wrist, carrying a small piece of unexposed X-ray film. This, when developed at the end of the day, will show up any scattered X-radiation to which the wearer may have been harmfully exposed. General Electric Co., Schenectady, N. Y.

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